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Posttest Metallurgical Evaluation Results for Steel Containment Vessel (SCV) High Pressure Test

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Abstract

The Nuclear Power Engineering Corporation (NUPEC) of Japan and the US Nuclear Regulatory Commission (NRC), Office of Nuclear Regulatory Research, are co-sponsoring and jointly funding a Cooperative Containment Research Program at Sandia National Laboratories. As a part of this program, a steel containment vessel (SCV) model was tested to failure in the high pressure test on December 11–12, 1996. The model, which is representative of a steel containment for an improved Japanese Mark II Boiling Water Reactor Plant, has a geometric scale of 1:10 and a thickness scale of 1:4. The objectives of the SCV model test were to obtain measurement data of the structural response of the model up to its failure in order to validate analytical modeling, to find the pressure capacity of the model, and to observe the failure mechanisms.

The SCV model was nitrogen pressure tested until leaking was detected. Deformation in the model produced different types of damage at several locations. Damage included tears, localized plastic deformation and necking, and general plastic strain. This report examines each damage site to determine the damage mechanisms and to assess whether factors such as alloy properties, assembly procedures, or pre-existing flaws could have contributed to the observed features.

Damage locations on the interior and exterior walls of the model were visually inspected and photographed. Pieces containing damage sites were cut out of the model wall; these were further sectioned for metallurgical analysis, which included optical microscopy, hardness tests, and fracture surface observations.

Tears produced in the model wall adjacent to the equipment hatch and at the opening in the middle stiffener ring were the result of local plastic deformation and ductile shear fracture. At

similar symmetrical locations in the structure, local necking without tearing was also observed. No contributing flaws in the model wall were noted at these locations.

Two types of steel microstructures were found: one typical of a ferritic and pearlitic hot-rolled steel, and one characteristic of a higher hardness low-carbon martensitic/bainitic steel (presumably specified for more highly stressed areas). Heat from the welding process of the SCV model resulted in localized microstructural alteration and reduced hardness and strength in the martensitic/bainitic steel. When the model was pressurized, plastic deformation occurred preferentially in these softer areas, eventually resulting in shear failure adjacent to the weld.

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1. Introduction

This report details the results of a visual and metallurgical analysis of the steel containment vessel (SCV) model after the high pressure test which caused damage at several locations on the model. The high pressure test was performed December 11–12, 1996. During the test, dry nitrogen gas at ambient temperature was pumped into the model to a maximum pressure of 4.66 MPa, when leaking was noted. The test lasted approximately 16.5 hours. The purpose of this analysis is to determine the extent that the condition and properties (such as microstructure, strength, ductility, or flaws) of the two steels, SGV480 and SPV490, and assembly features contributed to the damage observed at each location. In particular, this analysis attempts to assess whether the damage was "premature," resulting from existing properties of the steels. Findings from this report should be evaluated in conjunction with the results of the posttest model analysis in order to complete a comprehensive failure analysis of the model.

2. Description of SCV Model

The SCV model is a mixed-scale model, with 1:10 in containment geometry and 1:4 in shell thickness from a prototype Improved Mark II Boiling Water Reactor (BWR) containment structure, of a reactor containment vessel constructed of welded steel plate of several thicknesses (Figure 2-1). Wall thicknesses vary from 6 to 9 mm in the top two-thirds of the structure; the bottom hemisphere is much thicker (38–50 mm). During the test, the upper portion of the vessel was surrounded by a 38-mm-thick contact structure which limited the outward expansion of the SCV model as the pressure increased. The contact structure was removed after the test to permit observations of the outside surface of the model. An equipment hatch (EQH) is built into the side of the model at approximately 2.9 m up from the bottom; it is welded into a ring of thicker (17.5 mm) alloy. The structure also contains internal circumferential stiffener rings at four vertical locations.

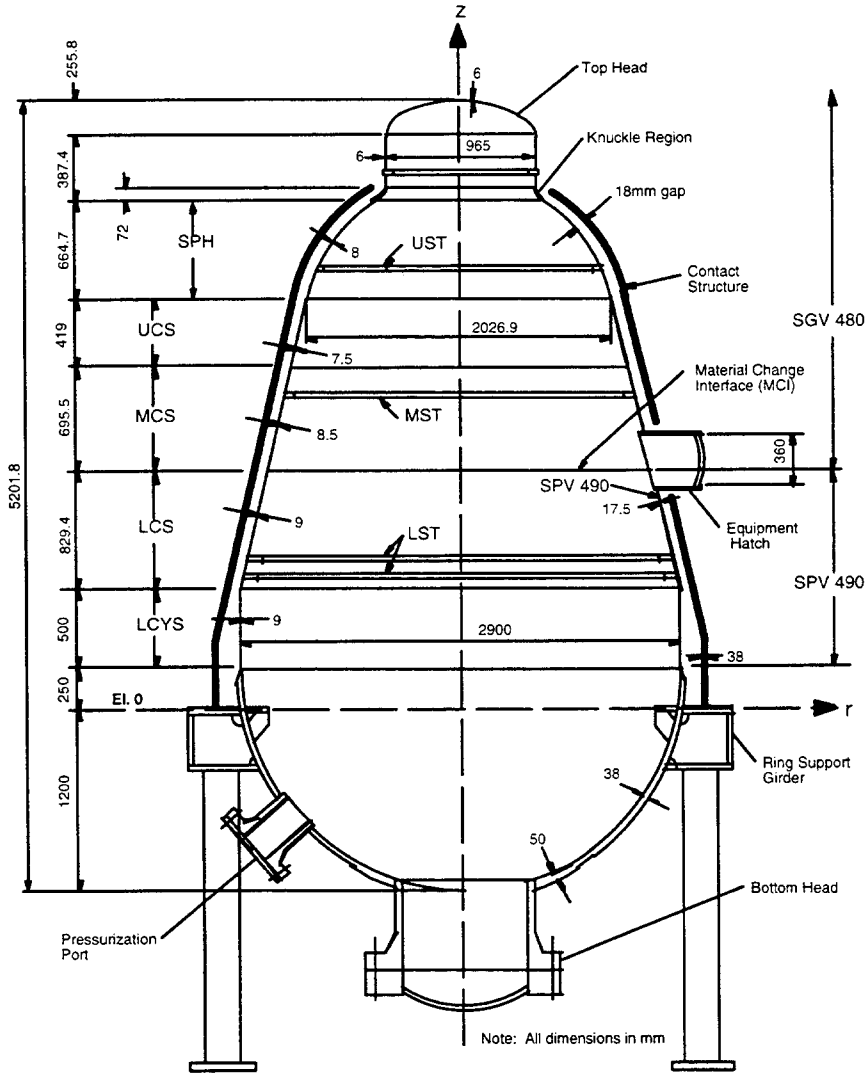
An "unrolled" 360° elevation view of the model wall from the outside is shown in Figure 2-2; the area shown extends from the top of the bottom hemisphere to the top of the model. Positions along the circumference are given in degrees (e.g., the equipment hatch is located at the 90° location). Figure 2-2 also shows the stiffener ring positions.

3. Description of Damage and Sample Locations

Three types of localized damage regions were observed on the model. These are discussed in detail in following sections of this report. Damage locations and approximate sizes of sections cut from the model are given in Figure 2-2.

1. At the equipment hatch, a tear formed at the 74° azimuth at the junction of the hatch reinforcement plate and the 9 mm lower conical shell section (LCS) plate material. Symmetrically on the other side of the hatch at the 106° location, a localized neck formed at the similar position (Figure 3-1).

2. Damage occurred at two locations 180° apart, associated with the middle stiffener (MST) ring. A tear formed in the model wall below a weld relief hole in the stiffener ring (Figure 3-2) at position 201°, and a local neck formed in the similar location at 21°.



Nomenclature:

Location Designation	Description
THD	top head
KNU	knuckle
SPH	spherical shell
UST	upper stiffener
UCS	upper conical shell
MST	middle stiffener
MCS	middle conical shell
MCI	material change interface
LCS	lower conical shell
LST	lower stiffeners
LCYS	lower cylindrical shell

Figure 2-1. SCV model elevations and material thickness.

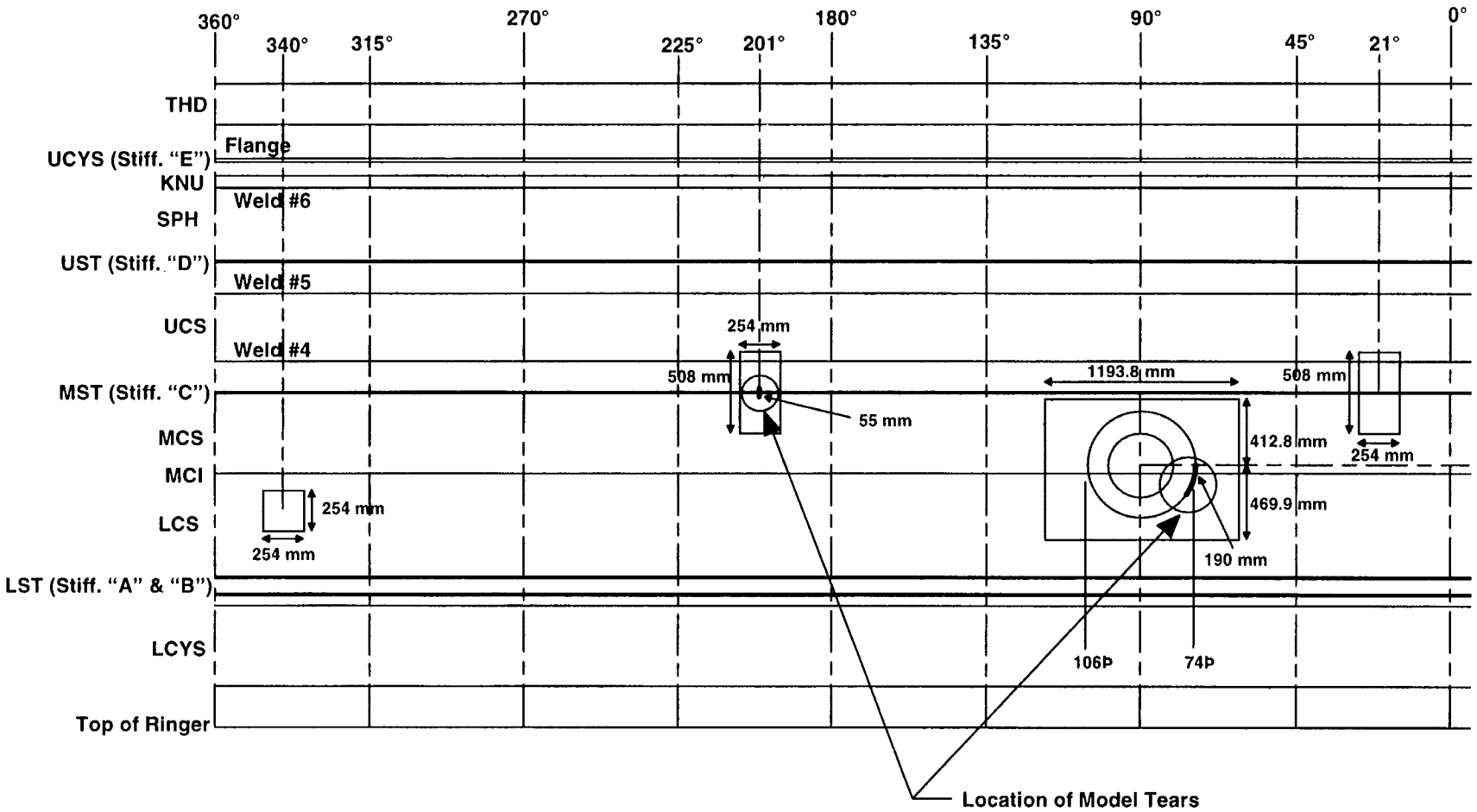


Figure 2-2. Elevation view of SCV model wall showing sampling locations.

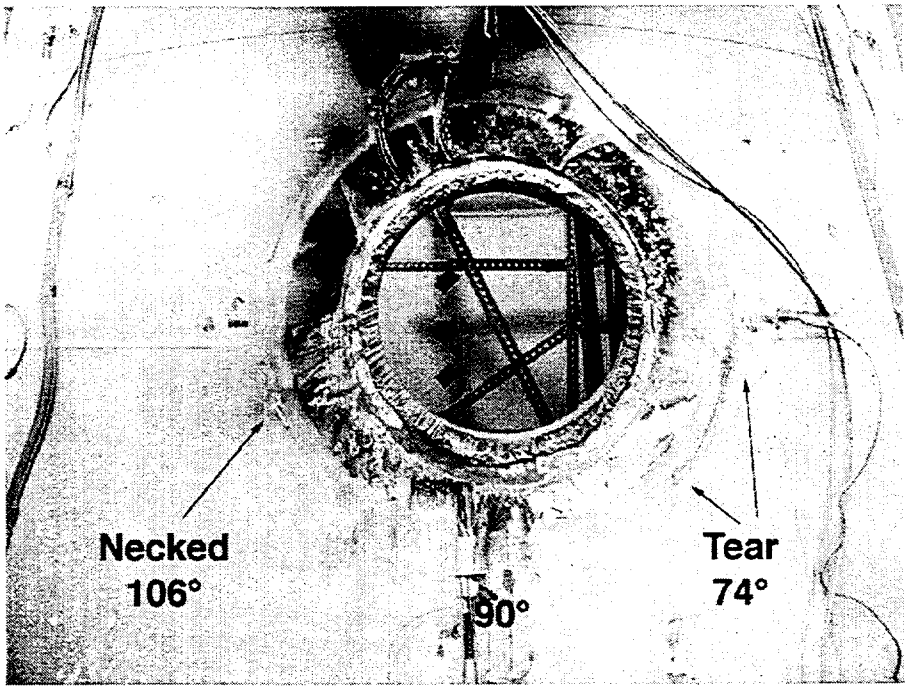


Figure 3-1. **Exterior view of the equipment hatch (after removal of the barrel) showing torn and necked locations.**

Figure 3-2. **Interior view of wall tear in vertical weld below opening in MST stiffener. Dark material is residue of putty used to seal opening area for posttest leak test.**

3. Local necks formed within the vertical weld lines at the 160° and 340° positions which connect the two plates forming the LCS (Figure 3-3). These necks and other areas of local deformation on the outer surface of the model are visible because the paint coating is brittle and cracks.

3.1 Tear and Deformation at the Equipment Hatch (EQH)

The tear at the 74° position near the equipment hatch was approximately 190 mm long, with an additional several centimeters of localized necking extending from either end of the tear (Figure 3-4). The local deformation is evident from the cracked paint. An interior view of the same tear is shown in Figure 3-5; note the position of strain gages near the tear. Three samples were cut from the area of the tear for metallurgical analysis. These included SCV-74-1 and SCV-74-3, which came from the untorn locally deformed regions on either end of the tear, and were mounted and sectioned to examine the deformation and local microstructures. Sample SCV-74-2 spanned the tear, and its fracture surfaces were analyzed by scanning electron microscopy to determine failure mode.

The structurally equivalent location near the EQH at 106° showed similar localized necking deformation, however here the strain was not large enough to result in tearing (Figure 3-6). The total length of the local deformation was approximately 85 mm. On the interior, the deformation shows up as offsets in ink grid markings in the necked location (Figure 3-7). Two samples, SCV-106-1 and SCV-106-2, were cut from the necked region.

In both of these locations the high strain concentration followed the weld between the thick (17.5 mm) EQH reinforcement plate and the thinner steel plate of the vessel wall. In Figure 3-4 the horizontal measuring tape follows along the material change interface (MCI) along the line of the horizontal weld between model segments LCS (9-mm-thick SPV490 steel) and MCS (8.5-mm-thick SGV480 steel). The reinforcement plate is also SPV490 steel. The majority of the deformation and tearing occurred along the weld between the reinforcement plate and the lower LCS segment; however, the localized strain also followed across the horizontal weld into the thinner MCS material. Sample SCV-74-3 contained material from both alloys (the reinforcement plate and the MCS).

3.2 Tearing and Deformation at Openings in the MST Ring

The MST ring (19 mm thick, 55 mm wide) is welded circumferentially edge-on around the MCS vessel wall segment (8.5-mm-thick SGV480 steel). At locations 21° and 201°, 180° apart, there are semi-circular openings cut out of the stiffener next to the vessel wall to accommodate the vertical welds joining the steel plates forming the MCS. These holes are approximately 32 mm wide. A tear formed in the model wall at the weld relief opening in the stiffener ring at position 201°, and a local neck formed in the similar location at 21°. The tear and local necks are vertically oriented within the vertical weld. Figure 3-8 shows an external view of the torn area at 201°. The figure also shows sample SCV-201 which was cut out transverse to the tear direction; a similar sample was taken at location 21° (SCV-21).

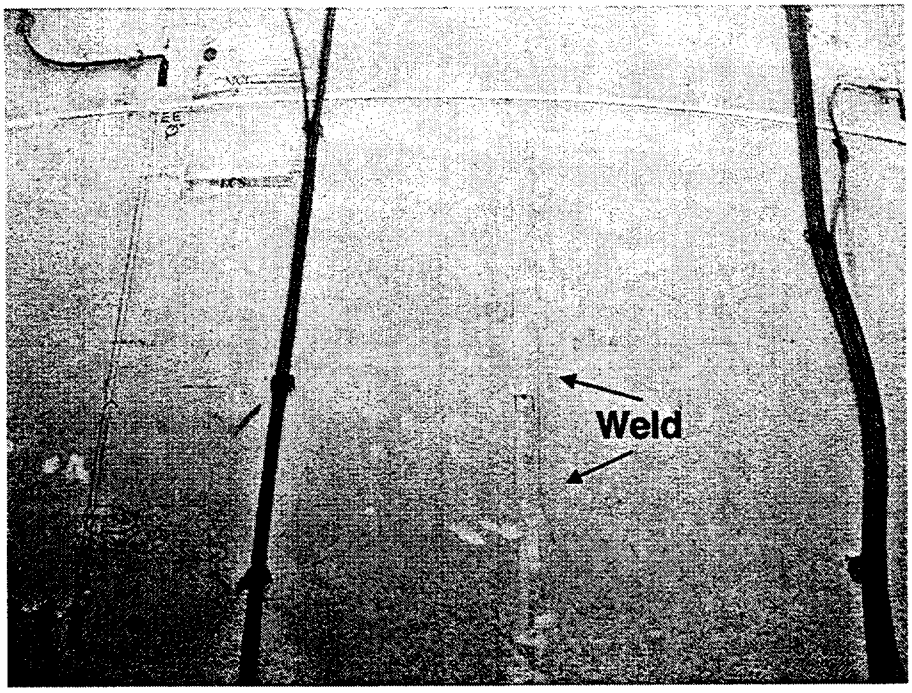


Figure 3-3. Overall external view of necked vertical weld in LCS model section.

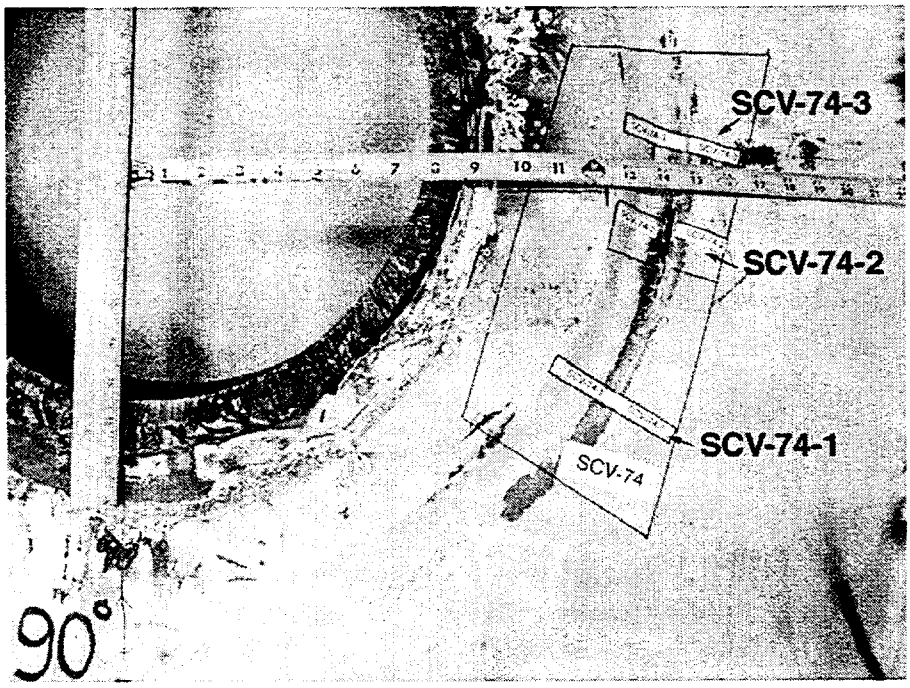


Figure 3-4. External view of EQH showing tear at 74° and sample locations (ruler marking in inches).

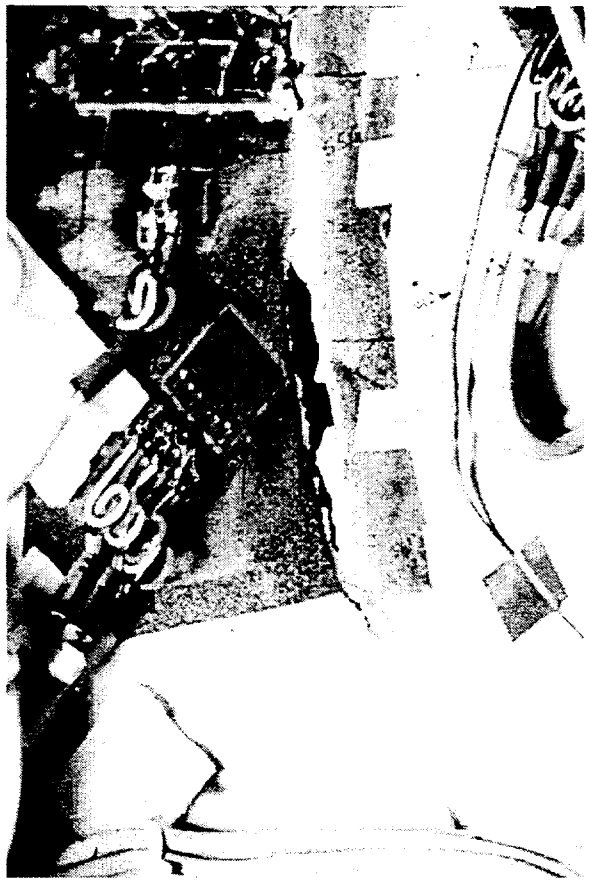


Figure 3-5. Interior view of tear at 74° location near the EQH.

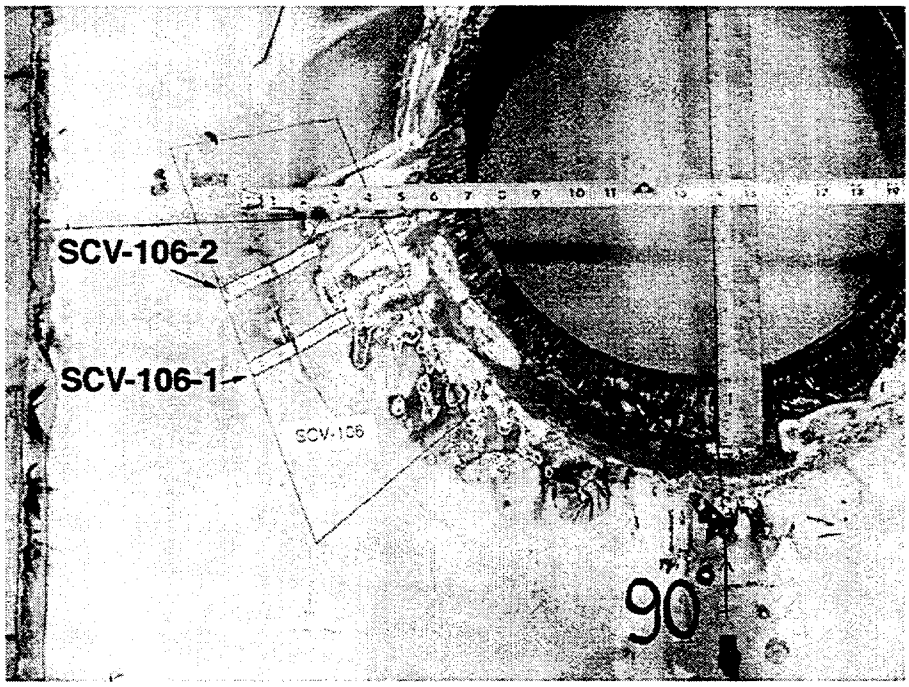


Figure 3-6. External view of EQH showing necked region at 106° and sample locations (ruler markings in inches).

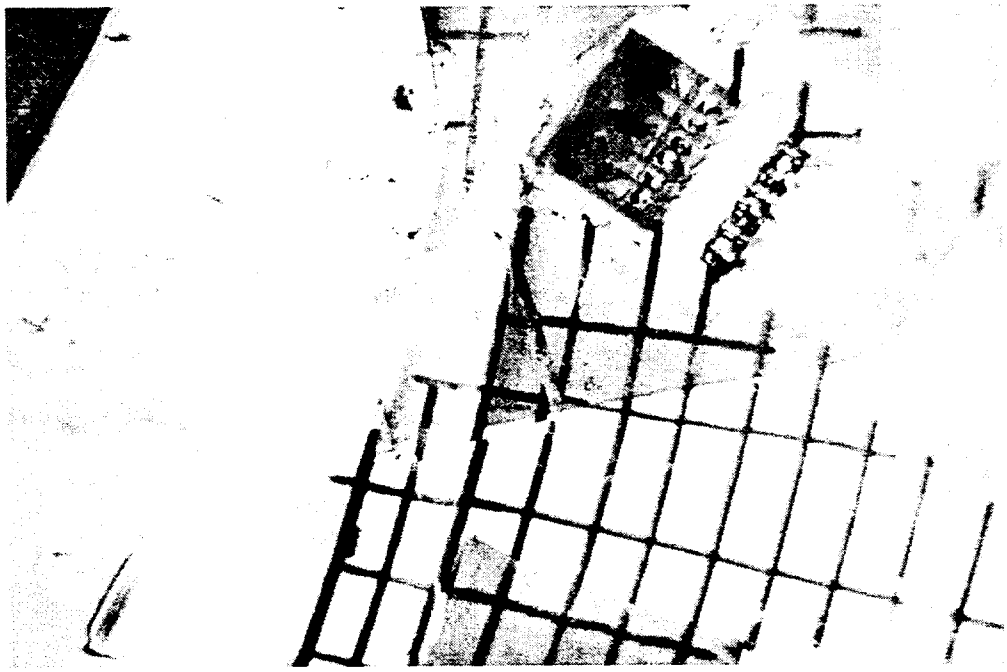


Figure 3-7. Internal view of EQH showing necked region at 106° with displacements.

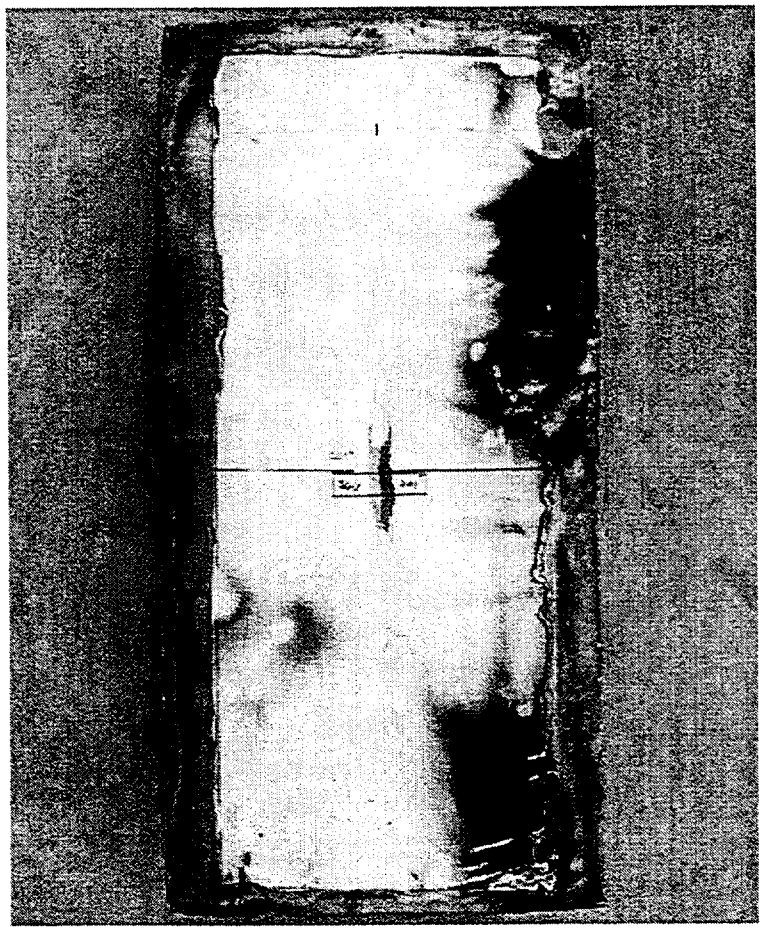


Figure 3-8. External view of tear below MST ring at 201°.

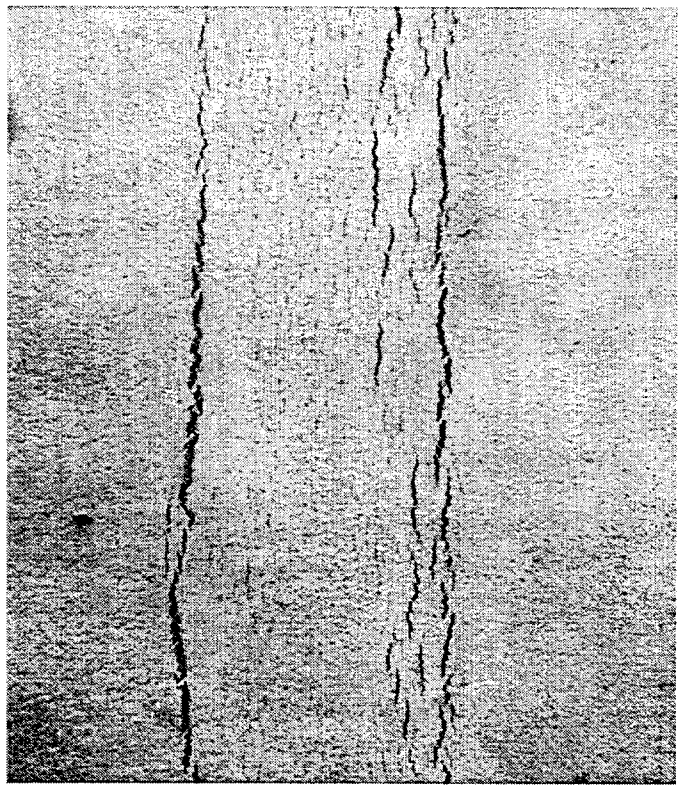


Figure 3-9. Closeup of exterior view of local deformation (causing cracks in paint) at the vertical weld in LCS at 340°.

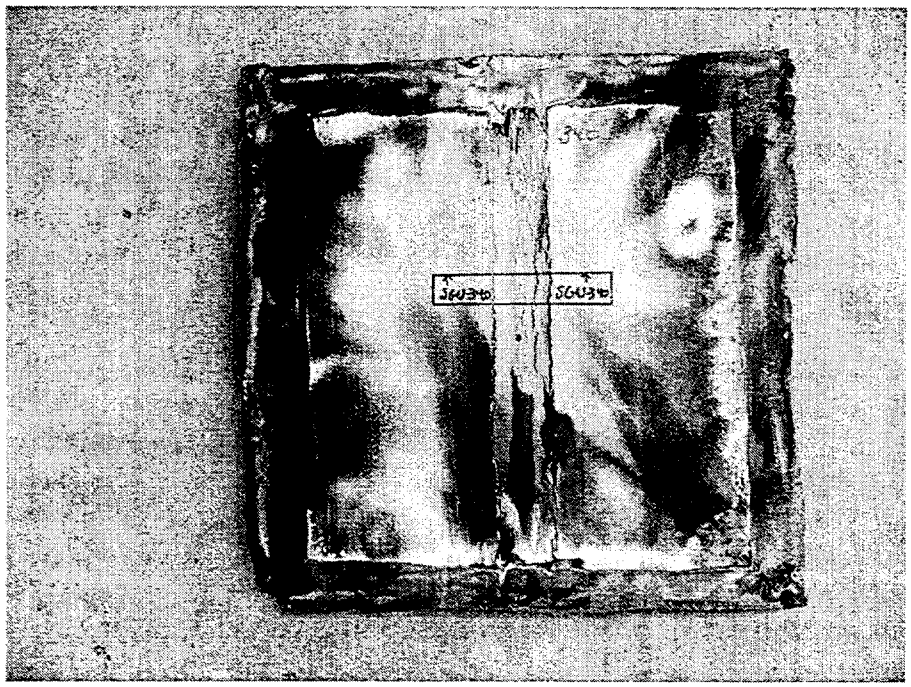


Figure 3-10. Sample SCV-340 taken from vertical weld in LCS at 340° (external view).

3.3 Localized Deformation at Vertical Welds in LCS Segment

Local necks formed within the vertical welds at the 160° and 340° positions which connect the two plates forming the LCS (Figure 3-3). These plates are 9-mm-thick SPV490 steel. A closeup external view of this deformation is given in Figure 3-9. A sample, SCV-340 was cut out for analysis (Figure 3-10).

4. Steel Alloy Microstructures and Properties

Table 4-1 gives reported compositions, strength, and ductility values for several thicknesses of the two alloys used to construct the model. These were taken from the material inspection certificates (see Appendix A). Analysis of polished cross-sections of the above samples showed that the two alloy steels were substantially different.

To characterize the relative strength levels of welds and alloy base metal at regions of the steel containment vessel (SCV) model where damage occurred, indentation hardness measurements were taken on the samples cut for metallurgical analysis. All hardness measurements, which used the Rockwell B scale, were calibrated to standard test blocks, and were taken in the thickness dimension of the steel plates. Sample surfaces were ground and polished. Hardness values were correlated to ultimate tensile strength using published tables for carbon steel (*ASM Metals Handbook*, 1967). Base metal hardness measurements were typically taken at the edge of the cut specimen, as far as possible from any weld within the sample. Base metal hardness would normally refer to metal plate which did not experience plastic deformation or any weld heating. In some cases, however, the "base metal" location may have experienced some heating from the weld process, and in all cases the "base metal" hardness was likely influenced by overall plastic strain in the SCV model wall.

4.1 Alloy SGV480

This material was found in sample SCV-21 and the thinner half of sample SCV-74-3. From its inspection certificates, it was specified to have 265 MPa minimum yield strength, 480 to 590 MPa ultimate tensile strength (UTS), and a minimum elongation of 15–17%, depending on thickness. The data shown in Table 4-1 and Appendix A indicate the material met these specifications.

This alloy's base metal microstructure was found to consist of a heavily banded ferrite and pearlite (Figure 4-1). This is typical of hot-rolled carbon steel. Its hardness was found to be 89.2 Rockwell B, suggesting an UTS of ~610 MPa (*ASM Metals Handbook,* 1967). Average hardness measurements are given in Table 4-2; a complete listing of all hardness values is given in Appendix B. This is ~10% higher than the reported UTS of 560 MPa, indicating that this material experienced net section yielding and a small amount of plastic deformation strain hardening during testing of the model. No undeformed material was available for hardness testing, since the SCV model experienced plastic deformation.

When welded, the reaustenitized heat affected zone (HAZ) transformed mostly to a ferrite and pearlite microstructure similar to, but somewhat finer than the base metal (Figure 4-2). Some

Table 4-1 SCV Steel Alloy Compositions and Properties from Inspection Certificates (Mechanical Properties: Transverse to the Rolling Direction)

Alloy	Thickness (mm)	Composition (%)	Yield Strength (MPa)	Tensile Strength (MPa)	Elongation (%)
SGV480	7.5	0.18 C, 0.23 Si, 1.16 Mn, 0.007 P, 0.001 S	403	556	26
SGV480	8	Same as above	389	532	26
SGV480	8.5	Same as above	411	560	24
SPV490	9	0.10 C, 0.24 Si, 1.29 Mn, 0.002 P, 0.001 S, 0.48 Ni, 0.03 Cr, 0.17 Mo, 0.04 V	710	727	27
SPV490	38	Same as above	566	650	45

portions immediately adjacent to the weld and near the surface (where very high temperatures resulted in very large austenite grains) transformed to a microstructure of Widmanstatten ferrite and pearlite (Figure 4-3). The Widmanstatten structure is a fine needle-like microstructure, as opposed to equiaxed grains of mixed ferrite and pearlite (compare Figures 4-3 and 4-9). It is a geometric microstructure that results from formation of a new phase along certain crystallographic planes of the parent solid solution phase. The Widmanstatten structure can form in many alloys with certain heat treatments or cooling rates. A few hardness measurements indicated that the heat affected zone was slightly harder than the base metal, 92.8 Rockwell B, because of its finer microstructure.

Based on the Widmanstatten microstructures, it is unlikely that the properties of this material would change significantly with variations in section thickness.

4.2 Alloy SPV490

This material was found in the thicker half of sample SCV-74-3, as well as in both halves of samples SCV-74-1, SCV-106-1, SCV-106-2, and SCV-340. It was specified to have 490 MPa minimum yield strength, 610 to 740 MPa ultimate tensile strength, and 18-25% elongation. Reported measured yield and ultimate tensile strengths (UTS) were 710 and 727 MPa, respectively, for the 9 mm plate material (Table 4-1). Strengths were substantially lower for the 38 mm material (566 and 650 MPa).

Base metal hardness measurements from an as-received reference plate of SPV490, which is not a part of the model, showed an average Rockwell B value of 98.8 ±0.7 (Table 4-2). This compares to an overall average base metal hardness from the cut samples of 97.4 Rockwell B, correlating to a UTS of ~733 MPa. This is consistent with the reported UTS of 727 MPa.

This alloy was found to have a much different microstructure typical of low-carbon martensite or bainite (Figure 4-4). This was most likely obtained by accelerated cooling from the hot rolling (or austenitizing) temperature (*ASM Metals Handbook,* 1990). SPV490 is clearly a more sophisticated steel than SGV480. This steel's higher strength is very likely due to the presence of carbon in solid solution or as finely divided carbides in the martensite or bainite, as well as finely divided vanadium carbonitrides (none of these is resolvable by optical metallography). Both result from a combination of alloying and a carefully controlled deformation and cooling sequence.

When welded, a much different microstructure develops in the reaustenitized heat affected zone. At 100× this microstructure appears significantly banded, indicating a pattern of chemical segregation that was not apparent in the martensitic/bainitic base metal (Figure 4-5). Higher magnification examination reveals the presence of a small amount of pearlite in the darker etching bands, consistent with 0.1% carbon (Figure 4-6). The remainder of the microstructure appears to consist of ferrite grains. In some areas these are fairly equiaxed, while in others they are more elongated and plate-like, typical of Widmanstatten ferrite or low-carbon martensite/bainite (Figure 4-7).

The heat affected zones (HAZs) were found to have significantly lower hardness, 90.7 Rockwell B in HAZs that had not been substantially deformed (Table 4-2). Measurements of undeformed HAZs were taken on the 17.5-mm-thick plate side of the welds, where the increased thickness did not allow plastic deformation. This suggests a HAZ ultimate tensile strength of ~625 MPa, 100 MPa lower than that of the base metal, and near the lower UTS design specification limit. More detailed hardness measurements indicated that the lowest HAZ hardness occurs near both sides of the boundary of the reaustenitized HAZ and the adjacent partially austenitized material, where the alloy was completely tempered, but not austenitized. These areas of lowest hardness are the logical result of heating causing removal of carbon from solid solution (or very finely divided carbides) through coarsening, as well as coarsening or resolution of fine carbonitride precipitates.

The band of reduced hardness is quite narrow, at least in the thick sections; it is approximately 2 to 3 mm wide in the thick (17.5 mm) sections of SPV490. Beyond that, the hardness seems roughly equivalent to that of the bulk base metal. The present samples do not permit measurement of the width of decreased hardness band in thin SPV490. This is where extensive deformation and necking occurred in the SCV samples.

The metallurgy of this steel, particularly the controlled cooling required to obtain the desired mechanical properties, makes it highly likely that properties would vary with section thickness. This apparently is responsible for the lower strengths reported in Table 4-1 for thicker sections of this material.

4.3 Weld Metal

Metallographic examination revealed that all of the welds were made in multiple passes. Frequently the initial passes were made on the inside of the model and the later passes on the outside. The microstructure of the final fusion zones consisted of large elongated prior-austenite grains in which the grain boundary regions had transformed to ferrite and the grain centers had

transformed to Widmanstatten ferrite and pearlite (Figure 4-8). The underlying prior fusion zones had been altered/transformed during subsequent weld passes, and consisted of much finer equiaxed ferrite grains and pearlite colonies (Figure 4-9). The hardness of the fusion zones (Table 4-2) was found to average Rockwell B 95.6, with the final fusion regions being slightly harder (~97), and the altered earlier passes being slightly softer (~94). No significant weld defects were observed in any of the samples.

Table 4-2. Hardness Values for SCV Samples

Listed in order are: Rockwell B Hardness Averages, Standard Deviations, and Numbers of Measurements

Sample	Material	Base Metal[a]	HAZ	Fusion Zone
SCV-74-1	SPV490	98.1 ±1.03 10	91.5 ±1.06 5	95.1 ±1.05 5
SCV-74-3	SPV490	94.2 ±0.39 5	90.9 ±1.80 5	92.1[b] ±0.96 5
"	SGV480	89.2 ±0.15 5	92.2[c] ±1.49 5	Same as above
SCV-106-1	SPV490	97.4 ±1.12 20	92.1 ±1.69 5	97.1 ±1.11 15
SCV-106-2	SPV490	97.0 ±1.34 15	88.6 ±1.04 5	95.0 ±2.58 10
SCV-340	SPV490	98.0 ±0.84 20	96.7[c] ±1.83 10	97.6 ±0.55 15
SCV-21	SGV480	88.8 ±1.26 5	92.8 ±0.56 4	95.5 ±0.92 6
SGV480 Avg.[d]		89.0	92.8	95.5
SPV490 Avg.[d]		97.4	90.7	96.2
SPV490 Reference Plate	SPV490	98.8 ±0.07 10		

[a] "Base Metal" measurements, except for the SPV490 Reference Plate, were taken at the far edges of sectioned samples; these samples experienced some plastic deformation, and the sample edges may have been heated during welding of the structure.

[b] Fusion zone between SGV480 and SPV490; not included in averages.

[c] HAZ deformed during pressurization of model; it is likely that hardness of material prior to deformation was lower; not included in averages.

[d] Weighted averages; more hardnesses measurements were made in some samples than others. See Appendix B.

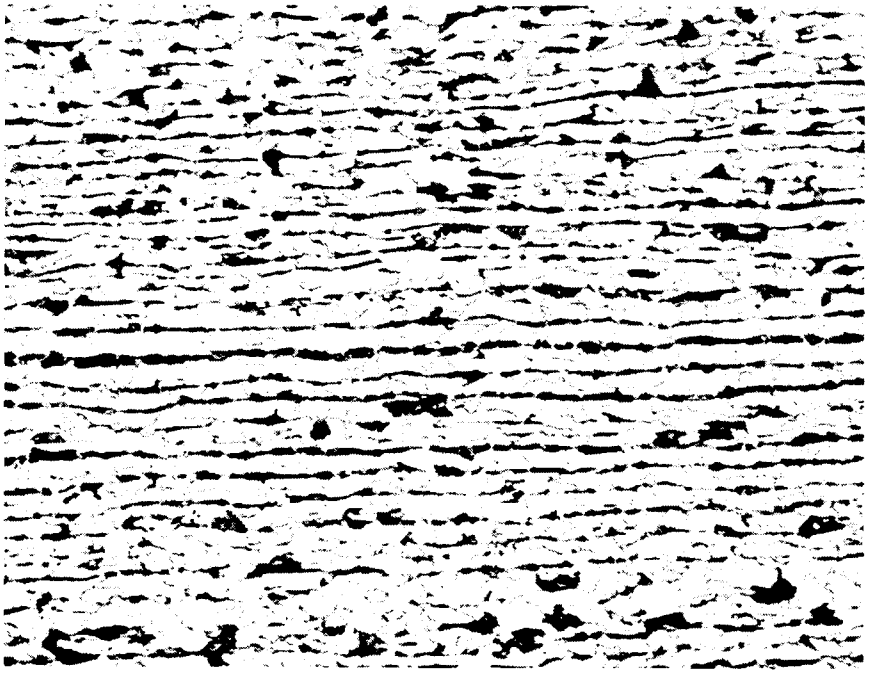


Figure 4-1. Banded ferrite and pearlite microstructure typical of SGV480 base metal, 400×.

Figure 4-2. Banded ferrite and pearlite microstructure typical of SGV480 heat affected zone, 400×.

Figure 4-3. Widmanstatten ferrite and pearlite microstructure seen in hottest regions of SGV480 heat affected zone, 400×.

Figure 4-4. Low-carbon martensite or bainite microstructure typical of SPV490 base metal, 400×.

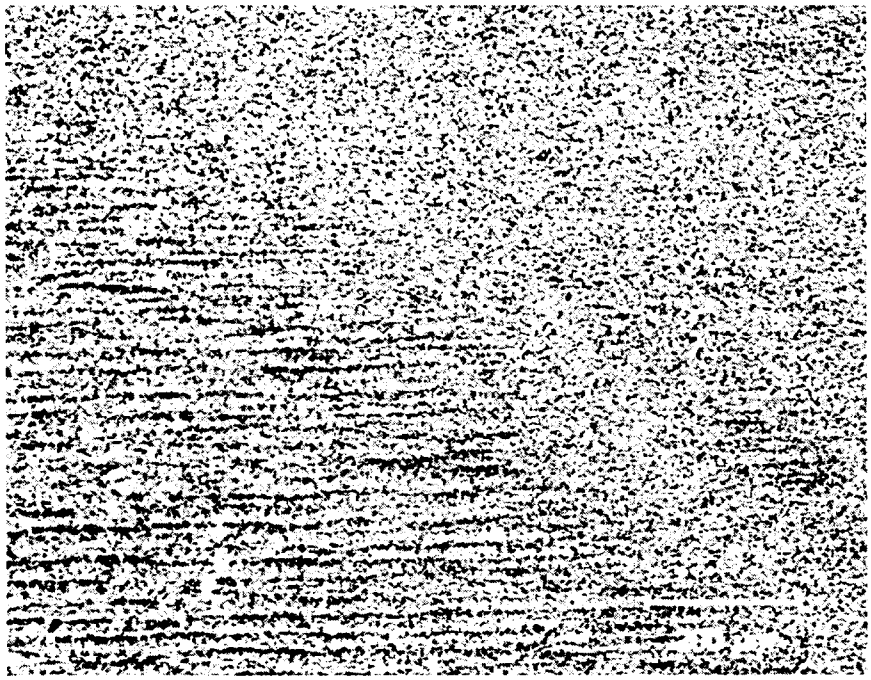


Figure 4-5. Banded microstructure typical of SPV490 heat affected zone, 100×.

Figure 4-6. Ferrite and pearlite microstructure typical of SPV490 heat affected zone, 400×.

Figure 4-7. Widmanstatten ferrite or low-carbon martensite/bainite microstructure seen in some areas of SPV490 heat affected zone, 400×.

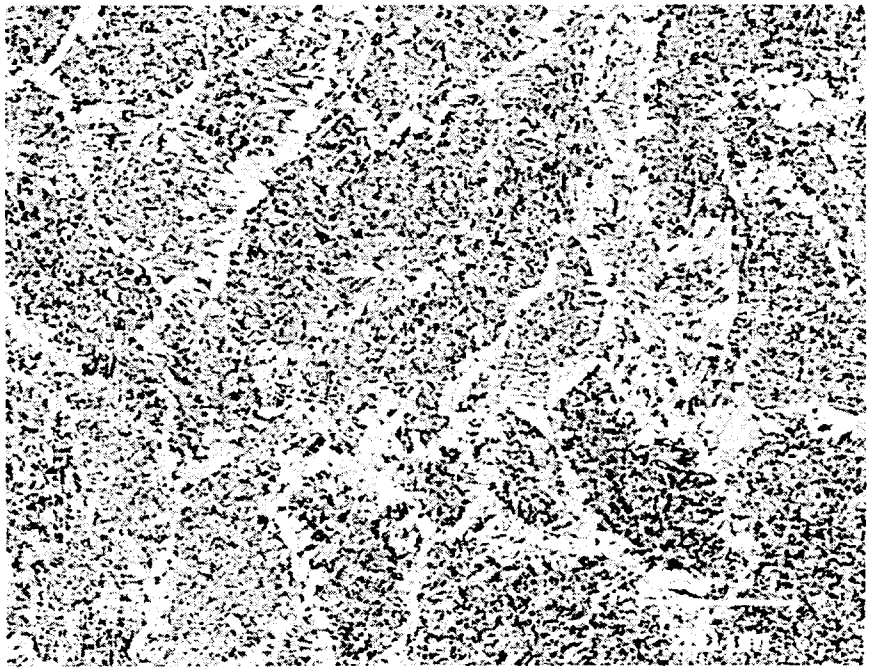


Figure 4-8. Widmanstatten ferrite and pearlite microstructure typical of last pass fusion zones in all samples, 100×.

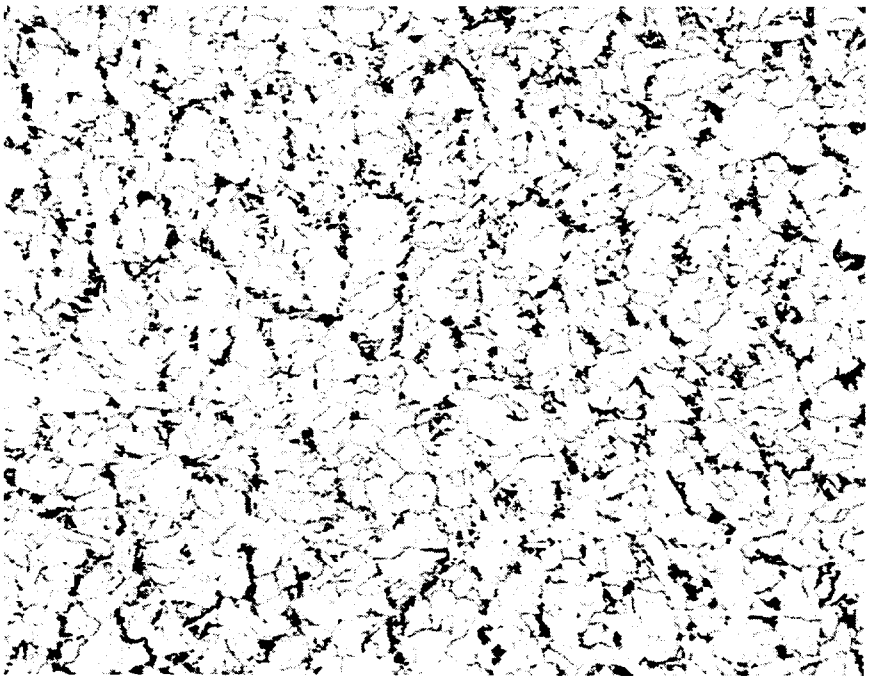


Figure 4-9. Equiaxed ferrite and pearlite microstructure typical of fusion zones altered by subsequent weld passes, 400×.

5. Metallographic Analysis of Damaged Regions

5.1 Samples from Damaged Region around EQH

The SCV model test was terminated when a ~190-mm-long tear developed in the wall adjacent to the equipment hatch at the 74° location. Macroexamination of the fracture surfaces indicated that this tear initiated in the 9-mm-thick SPV490 wall near where it was welded to the thicker reinforcement ring of the same material. The tear extended parallel to the weld from this initiation site in both directions, one half remaining in the 9 mm thick SPV490, and the other half crossing into the 8.5-mm-thick SGV480. The corresponding area on the opposite side of the equipment hatch at 106° exhibited substantial necking, but no tearing.

Seven samples were examined from the deformed and torn regions near the EQH: three from the fracture initiation region (SCV-74-2 A, B, and C), one from each end of the tear (SCV-74-1 and SCV-74-3), and two from the necked region on the opposite side of the equipment hatch (SCV-106-1 and SCV-106-2). Each sample consisted of a thin section of the model wall (8.5-mm-thick SGV480 in sample SCV-74-3, or 9-mm-thick SPV490 in all of the other samples) welded to a section of the thicker (17.5 mm) ring of SPV490 that surrounds the equipment hatch. The thickness reductions measured in each of these areas are shown in Table 5-1. It is apparent that both materials underwent substantial plastic deformation prior to tearing.

Metallographic examination of all of these samples revealed weld fusion zones, adjacent weld heat affected zones, and base metal microstructures. These are shown in Figures 5-1 through 5-6.

Table 5-1. Thickness Reduction Measured in Necked Regions of Each Sample

Sample	Material	% Thickness Reduction	Necking and Tear Location
SCV-74-2	SPV490	44.6[a]	HAZ
SCV-74-1	"	38.4[b]	HAZ
SCV-74-3	SGV480	41.5[b]	HAZ
SCV-106-1	SPV490	15.0	HAZ
SCV-106-2	"	31.1	HAZ
SCV-21	SGV480	12.8	HAZ
SCV-201	"	37.8	HAZ
SCV-340	SPV490	11.9 (side 1) 4.2 (side 2)	HAZ

[a] Near tear initiation site
[b] Just ahead of tear

In all cases necking was found to have concentrated in the weld heat affected zone. Eventual failure occurred by ~45-degree shear in these heavily deformed regions. No other flaws or provocative microstructural features were found to be associated with these failures.

Figure 5-1(a) shows the torn SPV490 HAZ near the lower end of the tear at the 74° location (Sample SCV-74-1). This weld connects the 9 mm SPV490 plate on the left to the 17.5-mm-thick SPV490 reinforcement plate around the EQH. The weld fusion zone, with at least five weld passes, is shown in Figure 5-1(b); the thicker plate is on the right. The necking and subsequent tearing is concentrated approximately 10 mm away from the fusion zone in the lower hardness region of the HAZ. Taken near the other (upper) end of the tear, Sample SCV-74-3 shows a similar view of the necked region in SGV480 plate in the HAZ of the weld to the EQH ring (Figure 5-2). The samples taken from the necked region on the other side (106°) of the EQH have the same appearance (Figures 5-3 and 5-4).

These figures, combined with hardness data discussed in Section 4.2, provide information to estimate the extent of thermal softening of the SPV490 alloy plate away from the welds. The HAZ is comprised of two regions: (1) a dark etching reaustentized part of the HAZ below the weld fusion zone, etched dark in Figures 5-1 through 5-4, and (2) a lightly etched band of reduced hardness next to the reaustenitized dark HAZ (measured to extend an additional 2 to 3 mm into the thick sections of SPV490). The reaustenitized HAZ depth ranges from 4 to 6 mm for both the thin and thick sides of the welds. This indicates that the depths of thermal penetration were similar for the two thicknesses. Because the band of reduced hardness in the metal adjacent to the reaustenitized portion (dark region) HAZ is approximately 2 to 3 mm wide in the thick

sections of SPV490, it is reasonable to conclude that the reduced hardness band in the thinner plate would also be on the order of 2 to 3 mm.

Metallographic examination of samples near the fracture initiation site (SCV-74-2 A, B, and C) revealed evidence of substantial local plastic shear deformation below the fracture surface near the inner and outer plate surfaces (Figure 5-5), but less local shear deformation in the interior of the model wall (Figure 5-6). *This suggests that failure initiated internally within the material, rather than at surface defects.*

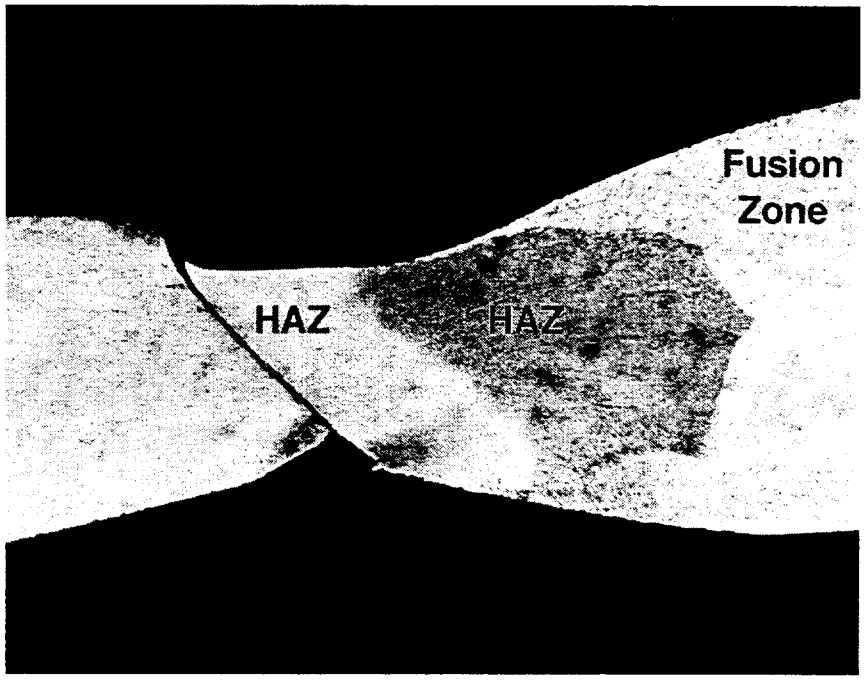
The fracture surface on Sample SCV-74-2 was examined in the scanning electron microscope (SEM) to determine tearing crack growth mode and to check for flaws or initiation sites. *The entire surface of the sample was comprised of ductile shear voids (Figure 5-7) characteristic of ductile shear overload failure.* No surface or subsurface flaws were noted. On these ductile shear void fracture surfaces, it was not possible to locate individual fracture initiation points. The fracture morphology seen here is consistent with ductile overload tearing failure, by shear, after the neck formed.

5.2 Samples from Damaged Region at Ring Stiffener/Wall Area

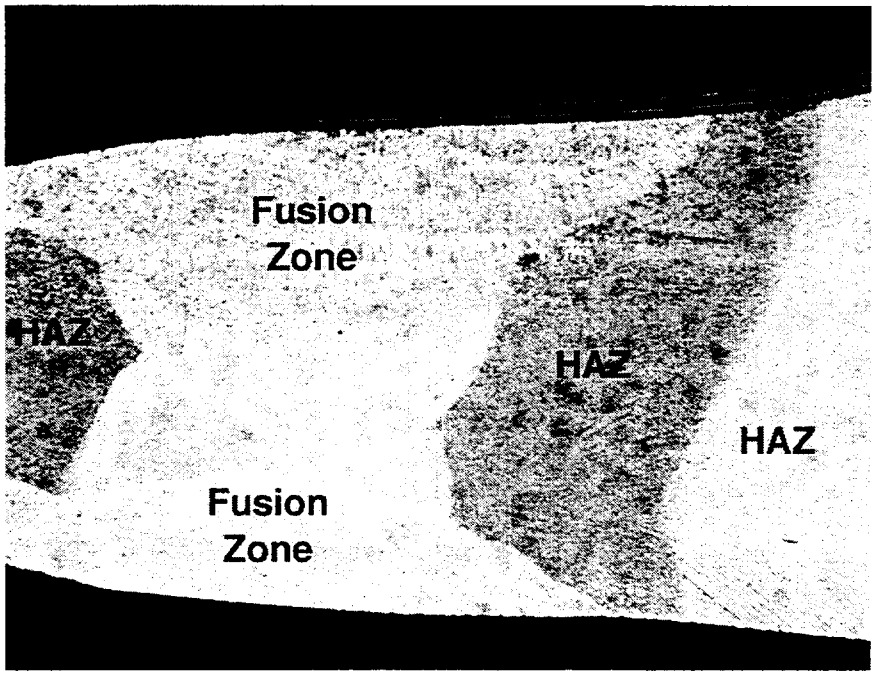
Sample SCV-21 at the 21° location consisted of two sections of 8.5 mm thick SGV480 wall (MCS) vertically welded together and then welded to a perpendicular plate stiffener ring of the same material. This ring was designed with an approximately 32-mm-wide opening adjacent to the inner model surface; the semi-circular openings are over the vertical welds. Deformation of the stiffener ring during pressurization caused localized plastic deformation of the wall at the opening and produced a vertical necked region within the vertical weld.

Sample SCV-21 consisted mostly of weld metal and heat affected zone (Figure 5-8). The sample is aligned along the direction of the stiffener ring, and the opening in the ring is captured in cross-section. The wall plate is at the bottom of the section, with the neck evident at the bottom of the opening (the model vertical direction is perpendicular to the micrograph). A wide variety of microstructures were observed, including the heavily banded ferrite and pearlite base metals, heat affected zones consisting of banded ferrite and pearlite or Widmanstatten ferrite and pearlite (where large austenite grains had formed from very high temperature exposure), decarburized areas where the opening had apparently been flame cut from the stiffener plate, and essentially pure iron weld metal which apparently had been used to build up various surfaces. The necked region is primarily composed of weld HAZ. The hardness of the wall was found to be consistent with that of the SGV480 wall material in sample SCV-74-3. The measured reduction-in-area measured in the wall adjacent to the stiffener cut-out is shown in Table 5-1.

The fracture surface of the tear in Sample SCV-201 was viewed in the SEM to determine the fracture mode (Figure 5-9). This tear formed primarily in shear as a ductile overload failure. The figure shows ductile shear voids on the surface. *No flaws were noted which would have contributed to premature failure.* The measured reduction-in-area measured in the wall adjacent to the stiffener cutout at 201° is shown in Table 5-1.

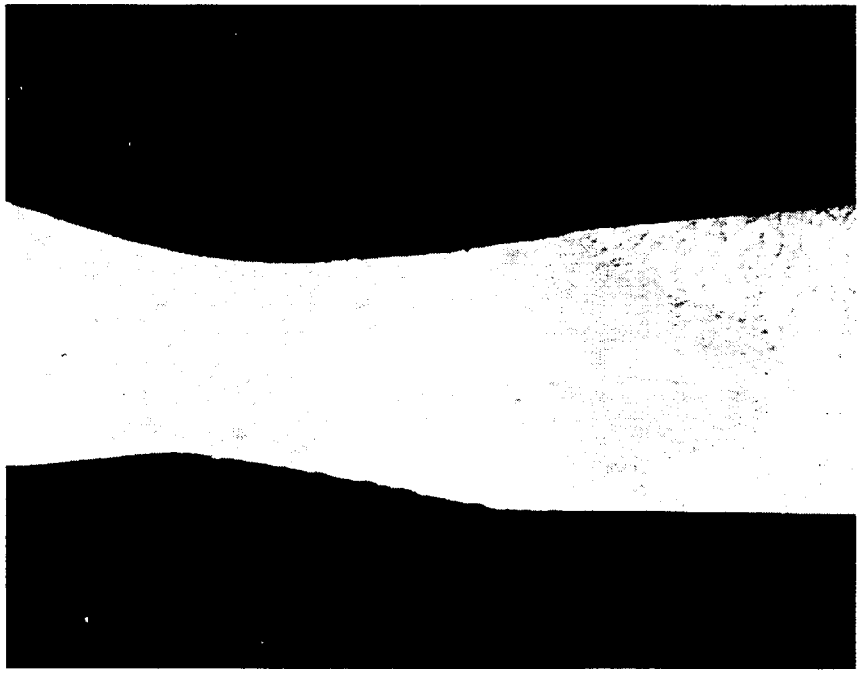


(a)

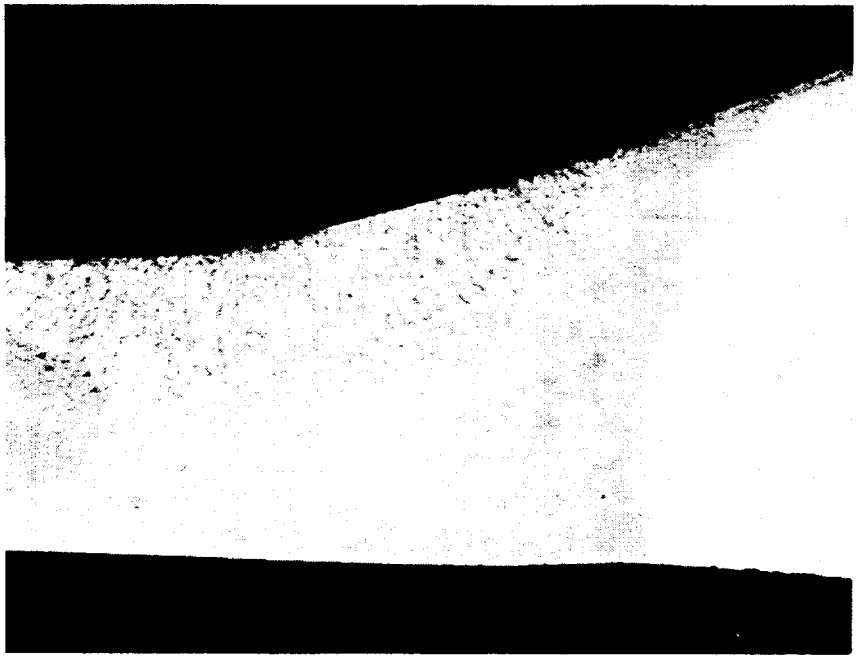


(b)

Figure 5-1. Sample SCV-74-1 near bottom of tear adjacent to EQH, 5×; (a) shear tear in lower hardness weld HAZ in 9 mm SPV490 wall material, with weld fusion zone on right; (b) view to right of (a) showing fusion zone and weld HAZ into 17.5 mm SPV490 reinforcement plate. Reaustenitized HAZ areas are dark regions on either side of fusion zone.

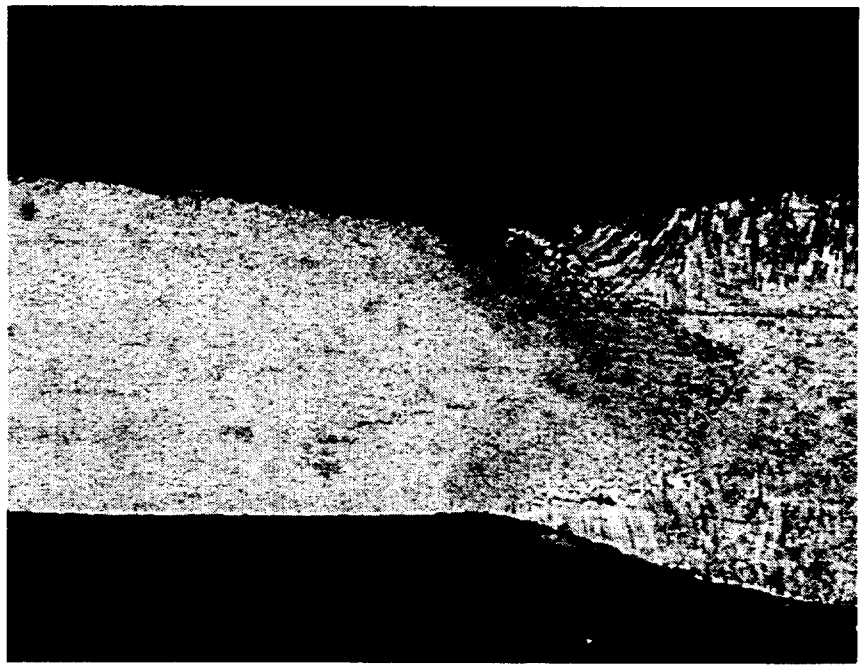


(a)

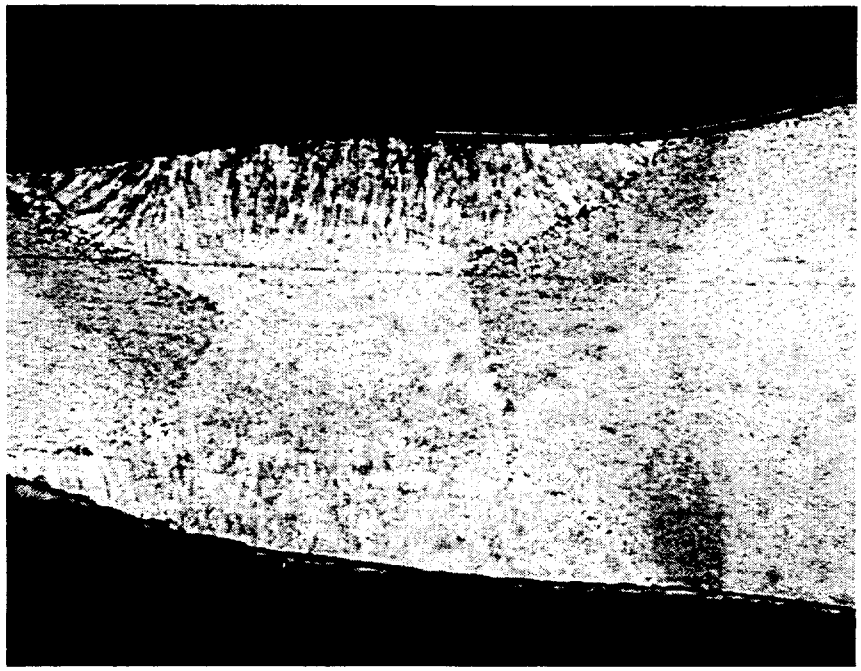


(b)

Figure 5-2. Sample SCV-74-3 near top of tear adjacent to EQH, 5×; (a) deformed and necked region in weld HAZ of 8.5 mm SGV480 wall material with weld fusion zone on right; (b) view to right of (a) showing fusion zone and weld HAZ into 17.5 mm SPV490 reinforcement plate.

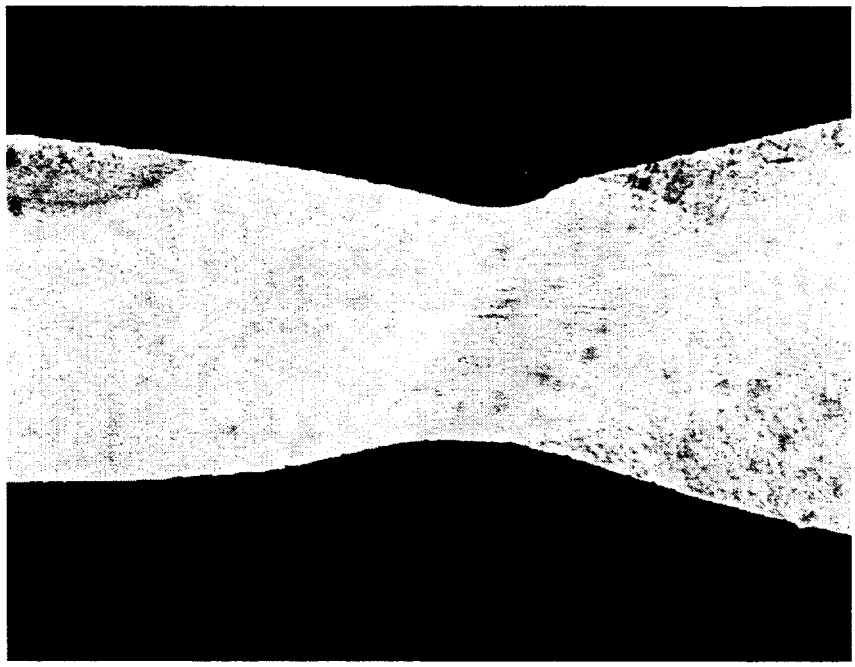


(a)

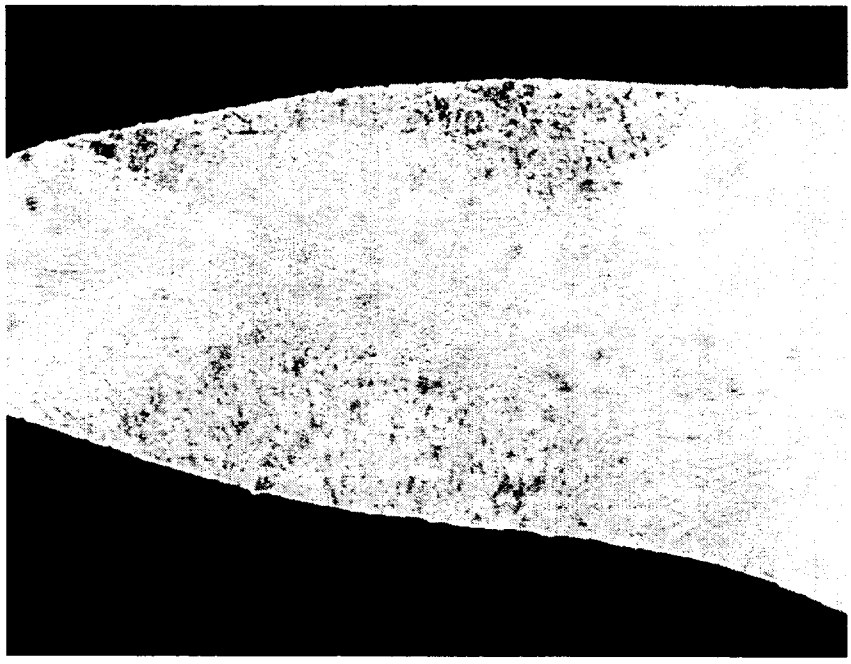


(b)

Figure 5-3. Microstructure of necked region at 106° location near EQH, sample SCV-106-1, 5×; (a) thinning deformation in weld HAZ in SPV490 alloy plate with weld fusion zone at right side; (b) view to right of (a) showing weld fusion zone and HAZ of 17.5 mm SPV490 reinforcement plate.



(a)



(b)

Figure 5-4. Microstructure of necked region at 106° location near EQH, sample SCV-106-2, 5×; (a) thinning deformation at base metal and weld HAZ in SPV490 alloy plate with weld fusion zone at right side; (b) view to right of (a) showing weld fusion zone and HAZ of 17.5 mm SPV490 reinforcement plate.

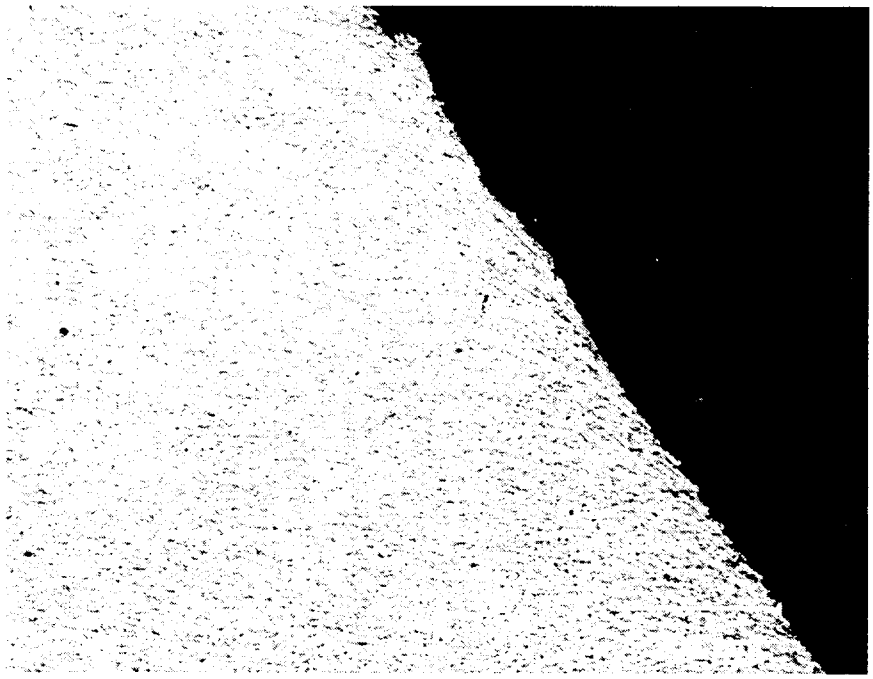


Figure 5-5. Local shearing associated in Sample SCV-74-2 with tearing near inner and outer surfaces near tear initiation site, and typical of the entire tear away from the initiation site, 100×.

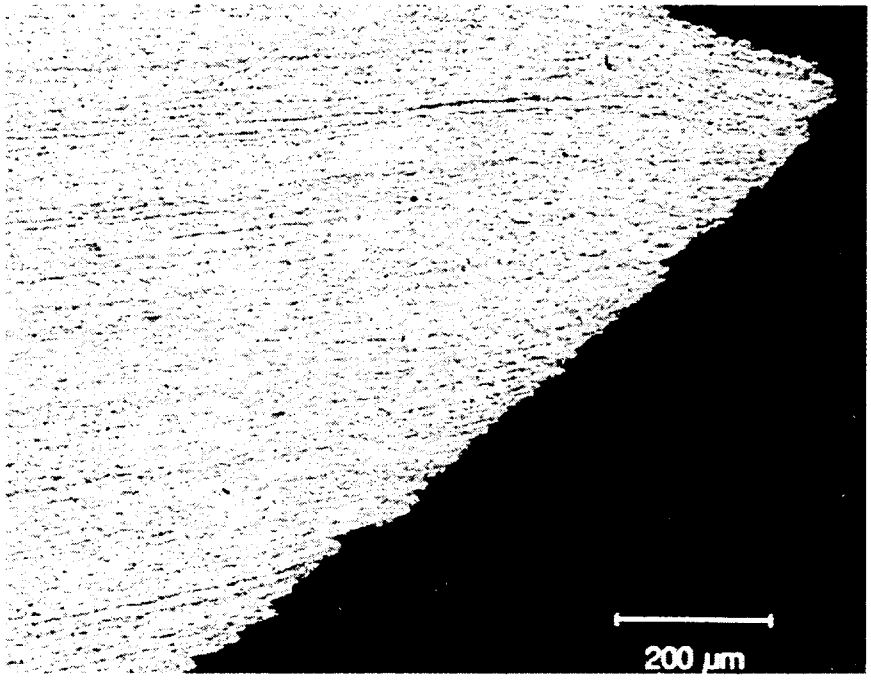


Figure 5-6. Relative absence of local shearing below the fracture surface in the interior of Sample SCV-74-2 denotes the actual fracture initiation site, 100×.

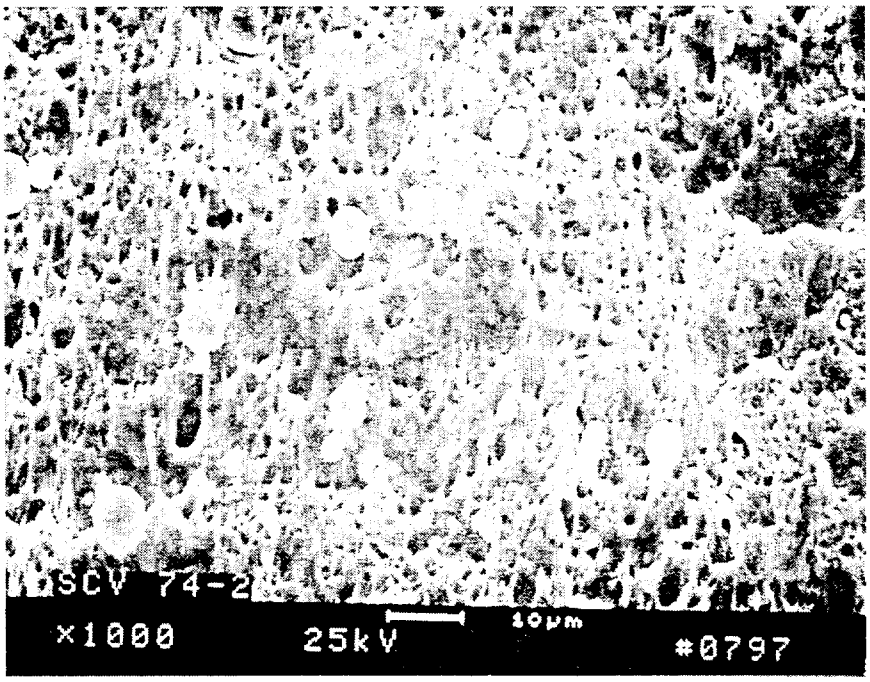


Figure 5-7. **SEM image of ductile shear fracture on tear surface of SCV-74-2 sample taken from tear near EQH (round balls are surface contaminates on the sample).**

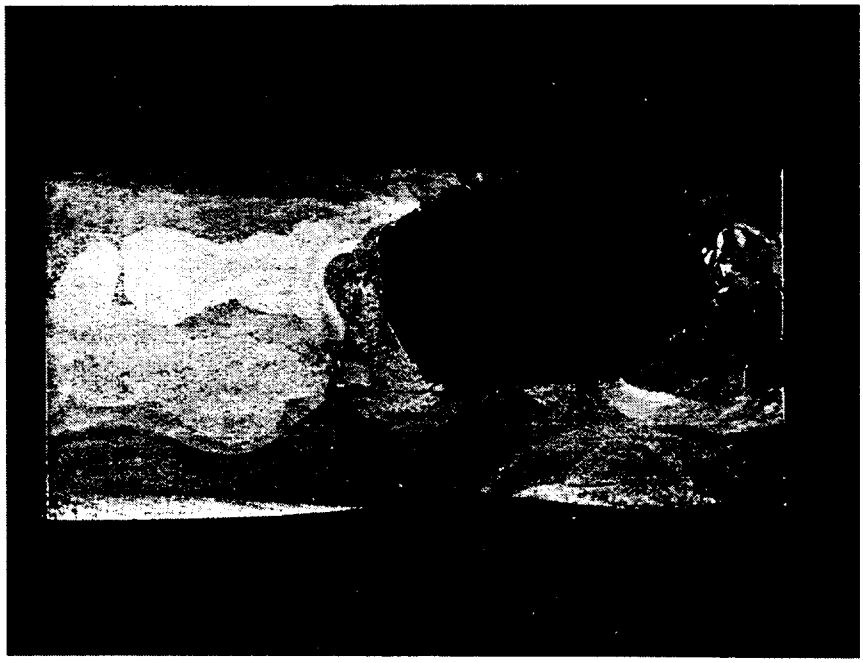


Figure 5-8. **Microstructure of Sample SCV-21. The neck in the vessel wall is located at the left side of the bottom of the hole in this view.**

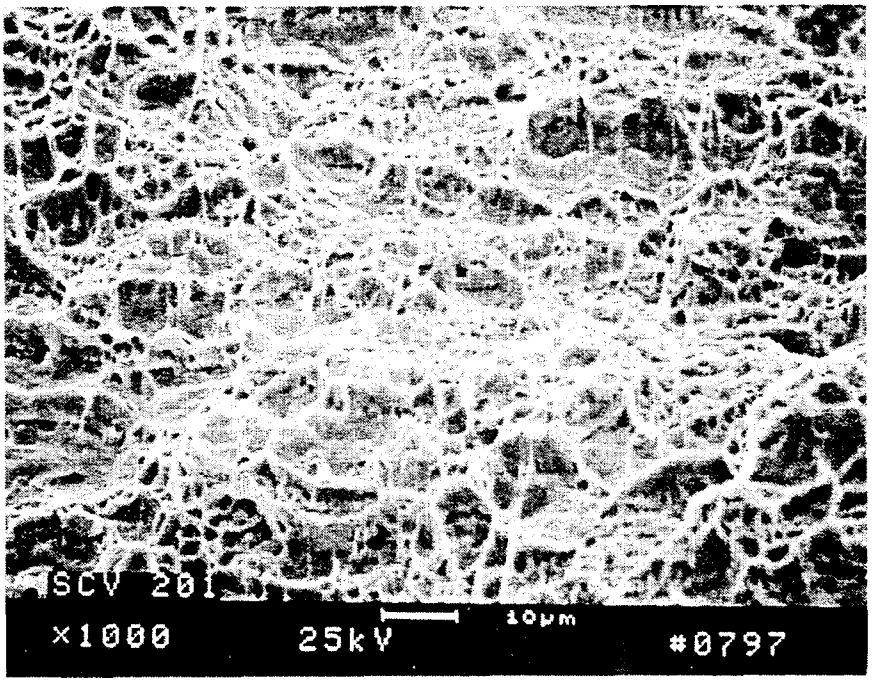


Figure 5-9. SEM image of ductile shear fracture on tear surface of SCV-201 sample taken from tear in wall below stiffener.

5.3 Samples from Deformed Vertical Weld Area

Sample SCV-340 consisted of two sections of 9 mm thick SPV490 welded vertically to one another. The microstructures and hardnesses of the fusion zone, heat affected zones, and base metal were similar to those described previously (Figure 5-10). Deformation was concentrated in the heat affected zones adjacent to each side of the weld, due to the low hardness in these regions. The reductions-in-area measured for each side of the weld are shown in Table 5-1.

6. Conclusions

1. Strong local necking deformation occurred at two locations around the equipment hatch; at one, the 74° location, a large stable shear tear formed which caused a leak in the model. These deformations occurred preferentially in the weld heat affected region of the SPV490 plate.

2. Hardness measurements and metallographic analysis indicate that in the SCV model heat from the welding process resulted in localized microstructural alteration and reduced hardness and strength of the SPV490 alloy plate. The region of reduced hardness adjacent to the weld included the reaustenitized (dark etching) weld heat affected zone, 4 to 6 mm wide, and a narrow zone of reduced hardness HAZ, approximately 2 to 3 mm wide. The weld fusion zone was not significantly softer than the SPV490 base metal.

3. A second tear formed in the model wall, at a weld relief opening in a stiffener ring, at the 201° location where a vertical weld joined plates of SGV480 steel. A similar region at 21° formed a localized neck. These deformations also occurred within the weld heat affected region.

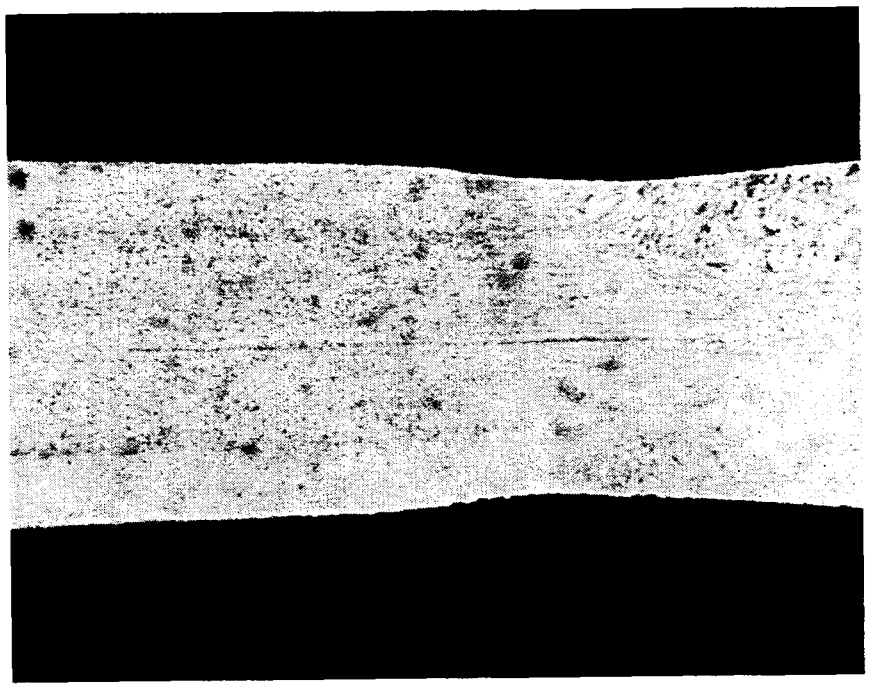
4. The microstructure and hardening mechanisms present in the SPV490 alloy make it sensitive to thermal history from the forming or welding process. The SGV480 alloy is less sensitive because of its simpler microstructure and chemistry.

5. All material deformation and fracture observed in the samples were ductile in nature. There was no evidence of material flaws, defects, or brittle behavior in the base metal or welds. The tears that occurred resulted from exceeding the local plastic ductility of the alloy. Measured fracture ductilities at the tear locations were consistent with the ductilities reported on the inspection certificates for the materials used to construct the model.

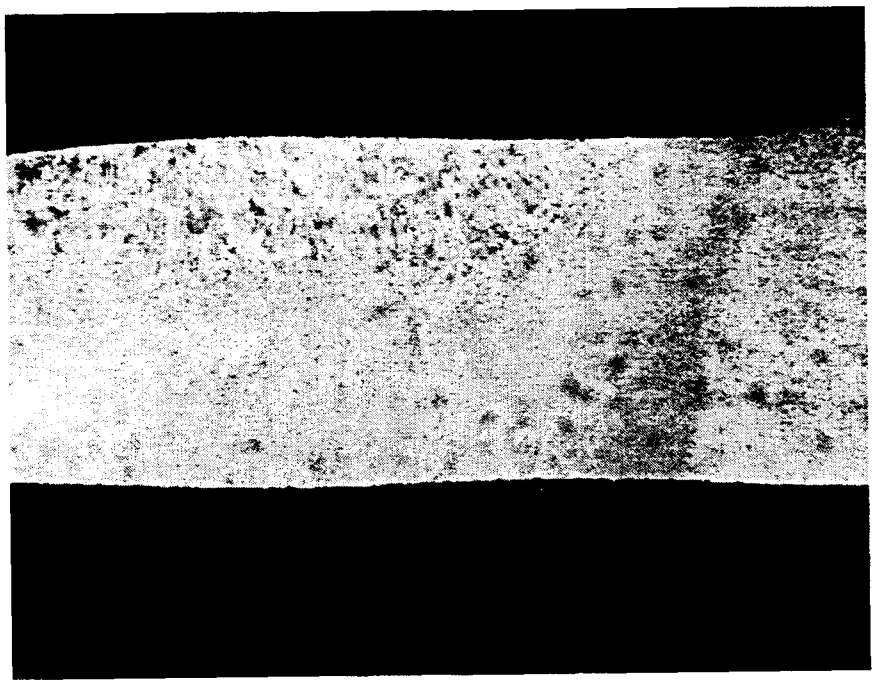
7. References

ASM Metals Handbook, 8th ed. 1967. pp. 1234–1236.

ASM Metals Handbook, 10th ed., Vol. 1. 1990. "High Strength Structural and High Strength Low Alloy Steels," especially "Acicular ferrite/low-carbon bainite steels," pp. 404–405.



(a)



(b)

Figure 5-10. Cross-section microstructure of vertical weld at 340° between plates of 9 mm SPV490 steel, Sample SCV-340; (a) plate material at left, necked HAZ at center, and weld fusion zone at right; (b) weld area to right of (a) showing, left to right, weld fusion zone, slightly necked HAZ, and 9 mm plate.

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Appendix A

Material Property Data and Inspection Certificates

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Material property data

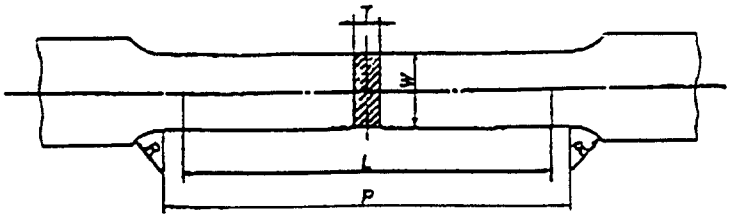
This is a response to Action item NS-93-S-004. We received material property test results from the mill. Table-1 shows yield strength (yield point), tensile strength and elongation which were tested by the mill. The shape of the test specimens are shown in Figure-1 and 2. These specimens were taken transverse to the rolling direction of the plate.

If SNL has any question, please let me know.

Table-1 Material property data

Material	Thickness (mm)	Y.P.		T.S.		El. (%)	Ref. No.
		(kg/mm^2)	(N/mm^2)	(kg/mm^2)	(N/mm^2)		
SGV49 (SGV480)	6	39.2	384	58.0	568	22	SGV49-1
	7.5	41.1	403	56.7	556	26	SGV49-2
	8	39.7	389	54.3	532	26	SGV49-3
	8.5	41.9	411	57.1	560	24	SGV49-4
	10	41.4	406	57.3	562	24	SGV49-5
	38	37.4	366	54.0	529	31	SGV49-6
SPV50 (SPV490)	9	72.4	710	74.2	727	27	SPV50-1
	9	71.2	698	73.3	718	27	SPV50-2
	38	57.8	566	66.3	650	45	SPV50-3

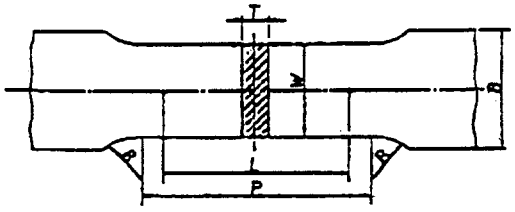
Y.P. : Yield Strength
T.S. : Tensile Strength
El. : Elongation



Unit: mm

Type of test piece	Width W	Gauge length L	Parallel length P	Radius of fillet R	Thickness T
1 A	40	200	approx. 220	25 min.	Thickness of material

Figure-1 Test specimen of SGV49



Unit: mm

Width W	Gauge length L	Parallel length P	Radius of fillet R	Thickness T
25	50	approx. 60	15 min.	Thickness of materials

Remark: In the case of applying this test piece to steel sheets not more than 3 mm thick, the radius R of fillet shall be 20 to 30 mm, and the width B of gripped ends shall be 30 mm or over.

Figure-2 Test specimen of SPV50

SGV49-1

検査証明書
INSPECTION CERTIFICATE

NKK 日本鋼管株式会社 NKK CORPORATION

本 社 ：〒100 東京都千代田区丸の内1丁目1番2号
Head Office: 1-1-2, MARUNOUCHI, CHIYODA-KU, TOKYO 100 JAPAN

注文者 Purchaser :HITACHI, LTD.-HITACHI
注文者注文番号 Purchaser's Order No. 9402700
取扱商社 Trading Co. :MARUBENI CORPORATION.
照合番号 Reference No. :0592 -DON1R549
品名 Commodity :HOT ROLLED STEEL PLATE
規格 Specification :JIS G3118 SGV480 1987

証明書番号 Certificate No. :AURNC-7962
日付 Date :1993-03-29
船名 Ship's No.
工事番号 Construction No. :088548
契約番号 Contract No. :AC1R549

Roll No. / Heat No.	Item No.	Size T X W X L (MM)	Quantity	Mass (CAL)	C ×100	Si ×100	Mn ×100	P ×1000	S ×1000	Y.P. N/MM2	T.S. N/MM2	EL %	Other
SPECIFIED VALUE (STANDARD)			LADLE	MIN.	-	15	85	-	-	265	480	15	BEND: R= 1.0XTHICK. AUSTENITE GRAIN SIZE : MIN. 5
				MAX.	27	30	120	35	40	-	590	-	
TO86001 / 13918	001	6 X 1000 X 3000	1	141	18	26	114	6	1	384	568	22	G; AUSTENITE GRAIN SIZE 7.5
TOTAL			1	141KGS									

VISUAL & DIMENSIONS : GOOD
HEAT TREATMENT CONDITION FOR PLATE
NORMALIZED : 900 °C X 27MIN.(A.C.)
(ROLL NO. T0860)

TEST SPECIMEN:
TENSILE: JIS NO. 1A
BEND : JIS NO. 1

(注) (Notes)
注1 圧延番号の表示法 Indication of Plate Roll Number
:1〜5番:母板番号 2 letters: the 1st 3 figures: mother Plate Number
:7〜8番:分割番号 the last 2 figures: divided Plate Number
注2 DD:脱ガス Degassed

注4 位置 Position
T:頂部 Top F:フランジ Flange B:底部 Bottom W:ウェブ Web
方向 Direction
L:圧延方向 Longitudinal
C:直角方向 Transverse
Z:板厚方向 Through-thickness

衝撃試験片寸法 Size of Impact Test Specimen
1:10x10mm 2:7.5x10mm 3:2/3x10mm 4:5x10mm 5:1/3x10mm 6:2.5x10mm 7:Thickness x 10mm
衝撃試験特性値単位 Unit of Impact Test Property
エネルギー Energy: K:kgf.m C:kgf.m/cm² J:Joule U:J/cm² F:ft.lbf
破面 Fracture: S:延性 Shear B:脆性 Brittle
横膨出 Lateral Expansion: M:mm I:mil

注5 標点距離 Gauge Length
A:200mm(*) D:50mm(*)
E:50mm(*) H:0"(*)
J:2"(*) K:50(*)
M:5.65√(*) P:5.65√(*)
R:40(*) S:80mm(*)
U:100mm(*) Y:2"(*)

BT :曲げ試験 Bend Test
UST:超音波探傷 Ultrasonic Examination
G :良 Good

H5-3-29 NOFEC

上記製品は規格の要求事項の試験に合格していることを証明いたします。 (CAF70001) (RPQ82743)

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN TESTED AND INSPECTED WITH SATISFACTORY RESULTS IN ACCORDANCE WITH THE REQUIREMENTS OF THE ABOVE SPECIFICATION.

INSPECTOR TO

京浜製鉄所：〒210 神奈川県川崎市川崎区南渡田町1番1号 KEIHIN WORKS: 1-1, MINAMIWATARIDA-CHO, KAWASAKI 210 JAPAN

M. Tanaka
京浜製鉄所検査室
Manager of Inspection Sec.

A-5

SGV49-2

検査証明書
INSPECTION CERTIFICATE

NKK 日本鋼管株式会社 NKK CORPORATION

本社：〒100東京都千代田区丸の内1丁目1番2号
Head Office:1-1-2, MARUNOUCHI, CHIYODA-KU, TOKYO 100 JAPAN

購買者 Purchaser :HITACHI, LTD.-HITACHI
購買者注文番号 Purchaser's Order No9402700
注文者 Trading Co. :MARUBENI CORPORATION.
注文者照合番号 Reference No. :B592 -DON1R555
品名 Commodity : HOT ROLLED STEEL PLATE
規格 Specification : JIS G3118 SGV480 1987

証明書番号 Certificate No. :AURHC-7965
日付 Date :1993-03-29
船名 Ship's No.
工事番号 Construction No. :088551
契約番号 Contract No. :AC1R555

Heat No. / Roll No.	Item No.	Purchaser's Order No. Size (MM) T X W X L	Quantity	Mass (CAL)	C x100	Si x100	Mn x100	P x1000	S x1000	Tensile Test Y.P N/MM2	T.S N/MM2	EL %	Bend Test	
SPECIFIED VALUE (STANDARD)			LADLE	MIN.	-	15	85	-	-	265	480	16		
				MAX.	27	30	120	35	40	-	590	-		
										BEND IR= 1.0XTHICK.				
										AUSTENITE GRAIN SIZE : MIN. 5				
SN91401 16D29	001	7.5 X 1500 X 4000	1	1553	18	23	116	7	1	BC 403	556	26	A	G
										TC				G
										AUSTENITE GRAIN SIZE ······ 10.0				
TOTAL			1	353KGS										

VISUAL & DIMENSIONS : GOOD
HEAT TREATMENT CONDITION FOR PLATE
NORMALIZED : 900 °C X 27MIN.(A.C)
(ROLL NO. SN914)

TEST SPECIMEN/
TENSILE: JIS NO. 1A
BEND : JIS NO. 1

(注) (Notes) 注1 Indication of Plate Roll Number
:1～5: 5 letters the 1st 3 figures:mother Plate Number
:the last 2 figures:divided Plate Number
注2 DG:Degassed

注4 Position
T:Top F:フランジ Flange 1:10X10mm 2:7.5X10mm 3:2/3X10mm 4:5X10mm
B:Bottom W:ウェブ Web 5:1/3X10mm 6:2.5X10mm 7:ThicknessX10mm
Direction
L:Longitudinal
C:Transverse
Z:Through-thickness

Size of Impact Test Specimen
Unit of Impact Test Property
Energy:K:kgf.m C:kgf.m/cm2 J:Joule.
U:J/cm2 F:ft.lbf
Fracture: S:Shear, B:Brittle
Lateral Expansion: M:mm I:mil

注5 Gauge Length
A:200mm(*) D:50mm(*)
E:50mm(*) H:8" (*)
J:2" (*) K:50(*)
M:5.65√(*) P:5.65√(*)
R:40(*) S:80mm(*)
U:100mm(*) Y:2" (*)

注6 BT :Bend Test
UST:Ultrasonic Examination
G :Good

H5-3-29. NUPEC 平5.7.29

上記商品は頭記の規格に合格していることを証明いたします。

(CAF71001) (RPQBZ743)

野中旭 吉田靖 財原研工部

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN TESTED AND INSPECTED WITH SATISFACTORY RESULTS IN ACCORDANCE WITH THE REQUIREMENTS OF THE ABOVE SPECIFICATION.

INSPECTOR TO

京浜製鉄所：〒210神奈川県川崎市川崎区南渡田町1番1号 KEIHIN WORKS:1-1, MINAMIWATARIDA-CHO, KAWASAKI 210 JAPAN

M. Tanaka

A-6

SGV49-3

検査証明書
INSPECTION CERTIFICATE

NKK 日本鋼管株式会社 NKK CORPORATION

本 社：〒100 東京都千代田区丸の内1丁目1番2号
Head Office: 1-1-2, MARUNOUCHI, CHIYODA-KU, TOKYO 100 JAPAN

購買者 Purchaser	:HITACHI, LTD.-HITACHI
購買者管理番号 Purchaser's Order No.	:8502700
注文者 Trading Co.	:MARUBENI CORPORATION.
注文者管理番号 Reference No.	:B592 -DGN1R543
品名 Commodity	:HOT ROLLED STEEL PLATE
規格 Specification	JIS G3118 SGV480 SR 1987
証明書番号 Certificate No.	:AURHC-7961
日付 Date	:1993-03-29
船名 Ship's No.	:
工事番号 Construction No.	:088547
契約番号 Contract No.	:AC1R543

製品番号 Roll No. / 鋼番 Heat No.	項番 Item No.	購買者管理番号(Ⅱ) Purchaser's Order No. / 寸法 Size (MM) T X W X L	員数 Quantity	質量 Mass (CAL)	C (X100)	Si (X100)	Mn (X100)	P (X1000)	S (X1000)	Tensile Test Y.P N/MM2	T.S N/MM2	El %	Bend
SPECIFIED VALUE (STANDARD)		LADLE		MIN.	-	15	85	-	-	265	480	17	
				MAX.	27	30	120	35	40	-	590	-	
										BEND: R= 1.0XTHICK.			
										AUSTENITE GRAIN SIZE : MIN. 5			
TF89201 16024	001	8 X 1500 X 3000	1	283	18	23	116	7	1	DC 389	532	26	O
										AUSTENITE GRAIN SIZE ······· 8.0			
		TOTAL	1	283KGS									

VISUAL & DIMENSIONS ; GOOD

HEAT TREATMENT CONDITION FOR PLATE
NORMALIZED : 900 °C X 20MIN. (A.C)
(ROLL NO. TF892)

HEAT TREATMENT CONDITION FOR TEST SPECIMEN
STRESS RELIEVED : 625 °C X 1HR.55MIN.
(ITEM NO. 001)

TEST SPECIMEN;
TENSILE: JIS NO. 1A
BEND : JIS NO. 1

(注) (Notes) 注1 Indication of Plate Roll Number
1550: 2 letter, the 1st 3 figures: mother Plate Number
T2: the last 2 figures: divided Plate Number
注2 DG: Degassed

注4 Position
T: Top F: Flange
B: Bottom W: Web
Direction
L: Longitudinal
C: Transverse
Z: Through-thickness

Size of Impact Test Specimen
1:10X10mm 2:7.5X10mm 3:2/3X10mm 4:5X10mm
5:1/3X10mm 6:2.5X10mm 7:ThicknessX10mm
Unit of Impact Test Property
Energy: K: kgf.m C: kgf.m/cm2 J: Joule.
U: J/cm2 F: ft. lbf
Fracture: S: Shear B: Brittle
Lateral Expansion: M: mm I: mil
注8 BT: Bend Test
UST: Ultrasonic Examination
O: Good

注5 Gauge Length
A: 200mm(*) D: 50mm(*)
E: 50mm(*) H: 8"(*)
J: 2"(*) K: 50(*)
M: 5.65√(*) P: 5.65√(*)
R: 4D(*) S: 80mm(*)
U: 100mm(*) Y: 2"(*)

H5-3-29 NUPEC H5.3.29

上記製品は貴注文の規格指定の規格に合格していることを証明いたします。

(CAF69002) (RPQBZ743)

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN TESTED AND INSPECTED WITH SATISFACTORY RESULTS IN ACCORDANCE WITH THE REQUIREMENTS OF THE ABOVE SPECIFICATION.

野中旭, 吉田頭 (?) 石井三郎
INSPECTOR TO

京浜製鉄所：〒210 神奈川県川崎市川崎区南渡田町1番1号 KEIHIN WORKS: 1-1, MINAMIWATARIDA-CHO, KAWASAKI 210 JAPAN

M. Tanaka
京浜製鉄所検査室
Manager of Inspection Sec.

A-7

A-8

SGV49-4

検査証明書
INSPECTION CERTIFICATE

NKK 日本鋼管株式会社 NKK CORPORATION

本社：〒100東京都千代田区丸の内1丁目1番2号
Head Office:1-1-2, MARUNOUCHI, CHIYODA-KU, TOKYO 100 JAPAN

Purchaser :HITACHI, LTD.-HITACHI
Purchaser's Order No. :8502700
Trading Co. :MARUBENI CORPORATION.
Reference No. :D592 -DON1R556
Commodity :HOT ROLLED STEEL PLATE
Specification :JIS G3118 SGV480 1987

Certificate No. :AURNC-7966
Date :1993-03-29
Ship's No.
Construction No. :088552
Contract No. :AC1R556

Roll No. / Heat No.	Item No.	Size (MM) T X W X L	Quantity	Mass (CAL)		C ×100	Si ×100	Mn ×100	P ×1000	S ×1000	Tensile Test Y.P N/MM2	T.S N/MM2	El %
SPECIFIED VALUE (STANDARD)			LADLE		MIN.	–	15	85	–	–	265	460	17
					MAX.	27	30	120	35	10	–	590	–
SN91501 16024	001	6.5 X 2500 X 4500	1	751		18	23	116	7	1	411	560	24
		TOTAL	1	751KGS									

BEND:R= 1.0XTHICK.
AUSTENITE GRAIN SIZE : MIN. 5
BC G
TC G
AUSTENITE GRAIN SIZE 10.0

VISUAL & DIMENSIONS : GOOD
HEAT TREATMENT CONDITION FOR PLATE
NORMALIZED : 900 °C X 27MIN.(A.C)
(ROLL NO. SN915)

TEST SPECIMEN;
TENSILE : JIS NO. 1A
BEND : JIS NO. 1

(注) (Notes)
1: Indication of Plate Roll Number
1st-5th: the 1st 3 figures: mother Plate Number
the last 2 figures: divided Plate Number
2: DG: Degassed

4: Position
T: Top F: Flange
B: Bottom W: Web
Direction
L: Longitudinal
C: Transverse
Z: Through-thickness

Size of Impact Test Specimen
1:10x10mm 2:7.5x10mm 3:2/3x10mm 4:5x10mm
5:1/3x10mm 6:2.5x10mm 7:Thickness x10mm
Unit of Impact Test Property
Energy: K:kgf.m C:kgf.m/cm² J:Joule.
U:J/cm² F:ft. lbf
Fracture: S:Shear B:Brittle
Lateral Expansion: M:mm I:mil

6: BT : Bend Test
UST: Ultrasonic Examination
G : Good

5: Gauge Length
A:200mm(*) D:80mm(*)
E:50mm(*) H:8"(*)
J:2"(*) K:5D(*)
M:5.65√A(*) P:5.65√A(*)
R:4D(*) S:80mm(*)
U:100mm(*) Y:2"(*)

(CAF71001) (RP4BZ743)

H5-3-29 NUPEC
野中旭，吉田隆 ... 研究部

上記製品は貴社の注文仕様の規格に合格していることを証明いたします。

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN TESTED AND INSPECTED WITH SATISFACTORY RESULTS IN ACCORDANCE WITH THE REQUIREMENTS OF THE ABOVE SPECIFICATION.

INSPECTOR TO

京浜製鉄所：〒210神奈川県川崎市川崎区南渡田町1番1号 KEIHIN WORKS:1-1, MINAMIWATARIDA-CHO, KAWASAKI 210 JAPAN

M. Tanaka
京浜製鉄所検査室長
Manager of Inspection Section

SGV49-5

検査証明書
INSPECTION CERTIFICATE

NKK 日本鋼管株式会社 NKK CORPORATION

本社：〒100東京都千代田区丸の内1丁目1番2号
Head Office:1-1-2, MARUNOUCHI, CHIYODA-KU, TOKYO 100 JAPAN

Purchaser :HITACHI, LTD.-HITACHI
Purchaser's Order No.8402700
Trading Co. :MARUBENI CORPORATION.
Reference No. :0592 -DGN1R551
Commodity : HOT ROLLED STEEL PLATE
Specification : JIS G3118 SGV480 1987

Certificate No. :AURNC-7964
Date :1993-03-29
Ship's No. :
Construction No. :088550
Contract No. :AC1R551

Roll No. / Heat No.	Item No.	Purchaser's Order No. / Size T X W X L (MM)	Quantity	Mass (CAL)	C x100	Si x100	Mn x100	P x1000	S x1000	Tensile Test Y.P N/MM2	T.S N/MM2	EL %	Remarks
SPECIFIED VALUE (STANDARD)			LADLE	MIN.	-	15	85	-	-	265	480	17	
				MAX.	27	30	120	35	40	-	590	-	
										BEND:R= 1.0XTHICK.			
										AUSTENITE GRAIN SIZE : MIN. 5			
SN91201 16024	001	10 X 3000 X 4500	1	1060	18	23	116	7	1	BC 406	562	24	G
										TC AUSTENITE GRAIN SIZE ······ 10.0			G
		TOTAL	1	1060KGS									

VISUAL & DIMENSIONS : GOOD
HEAT TREATMENT CONDITION FOR PLATE
NORMALIZED : 900 °C X 26MIN. (A.C)
(ROLL NO. SN912)

TEST SPECIMEN;
TENSILE : JIS NO. 1A
BEND : JIS NO. 1

(Notes) 注1 Indication of Plate Roll Number
125B: the 1st 3 figures: mother Plate Number
172B: the last 2 figures: divided Plate Number
注2 DG: Degassed

注4 Position
T: Top F: Flange 1:10x10mm 2:7.5x10mm 3:2/3x10mm 4:5x10mm
B: Bottom W: Web 5:1/3x10mm 6:2.5x10mm 7:Thicknessx10mm
Direction
L: Longitudinal
C: Transverse
Z: Through-thickness

Size of Impact Test Specimen
Unit of Impact Test Property
Energy: K:kgf.m C:kgf.m/cm² J:Joule
U:J/cm² F:ft.lbf
Fracture: S: Shear B: Brittle
Lateral Expansion: M:mm I:mil

注6 Gauge Length
A:200mm(*) O:50mm(*)
E:50mm(*) H:8"(*)
J:2"(*) K:5D(*)
M:5.65√(*) P:5.65√(*)
R:40(*) S:80mm(*)
U:100mm(*) Y:2"(*)

注8 BT: Bend Test
UST: Ultrasonic Examination
G: Good

H5-3-29. NUPEC 平5.3.29

上記製品は注文の規格指定の規格に合格していることを証明いたします
(CAF71001) (RP9B2743)

野中旭 吉田靖 曙研究所

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN TESTED AND INSPECTED WITH SATISFACTORY RESULTS IN ACCORDANCE WITH THE REQUIREMENTS OF THE ABOVE SPECIFICATION.

INSPECTOR TO

京浜製鉄所：〒210神奈川県川崎市川崎区南渡田町1番1号 KEIHIN WORKS:1-1, MINAMIWATARIDA-CHO, KAWASAKI 210 JAPAN

N. Tanaka
京浜製鉄所検査室長
Manager of Inspection Section

SGV49-6

検査証明書
INSPECTION CERTIFICATE

NKK 日本鋼管株式会社 NKK CORPORATION

本社：〒100 東京都千代田区丸の内1丁目1番2号
Head Office: 1-1-2, MARUNOUCHI, CHIYODA-KU, TOKYO 100 JAPAN

注文者 Purchaser	:HITACHI, LTD.-HITACHI.
注文者注文番号 Purchaser's Order No.	:9402700
注文者 Trading Co.	:MARUBENI CORPORATION.
注文者整理番号 Reference No.	:B592 -DGN1R550
品名 Commodity	:HOT ROLLED STEEL PLATE
規格 Specification	:JIS G3118 SGV480 1987
証明書番号 Certificate No.	:AURNC-7963
日付 Date	:1993-03-29
船名 Ship's No.	:
工事番号 Construction No.	:088549
契約番号 Contract No.	:AC1R550

Roll No. / Heat No.	Item No.	Purchaser's Order No. / Size T X W X L (MM)	Quantity	Mass (CAL)	C ×100	Si ×100	Mn ×100	P ×1000	S ×1000	Tensile Test Y.P N/MM2	T.S N/MM2	El %	Impact Test 1 / 3	2 / AVE	Notch Temp.
SPECIFIED VALUE (STANDARD)			LADLE	MIN.	-	15	85	-	-	265	480	140			
				MAX.	28	30	120	35	40	-	590	-			
										BEND: R= 1.0XT(180°).					
		(CUSTOMER'S SPEC.)								AUSTENITE GRAIN SIZE			MIN.	5	
													MIN.	2.1	2MM V EACH
													1K MIN.	2.8	-25°C AVE.
SN91301 16024	001	38 X 1000 X 3000	1	895	18	23	116	7	1	0C 366	529	31	G0C1K 23.2 / 19.0	20.7 / 21.0	2MM V -25°C
										AUSTENITE GRAIN SIZE				10.0	
		TOTAL	1	895KGS											

VISUAL & DIMENSIONS : GOOD
HEAT TREATMENT CONDITION FOR PLATE
NORMALIZED : 900 °C X 43MIN.(A.C)
(ROLL NO. SN913)

TEST SPECIMEN;
TENSILE : JIS NO. 1A
BEND : JIS NO. 1
IMPACT : JIS NO. 4

(注) (Notes) 1 Indication of Plate Roll Number
:1st 3 figures: mother Plate Number
:the last 2 figures: divided Plate Number
2 DG: Degassed

4 Position
T: Top F: Flange
B: Bottom W: Web
Direction
L: Longitudinal
C: Transverse
Z: Through-thickness

Size of Impact Test Specimen
1:10x10mm 2:7.5x10mm 3:2/3x10mm 4:5x10mm
5:1/3x10mm 6:2.5x10mm 7:Thickness x10mm
Unit of Impact Test Property
Energy: K: kgf.m C: kgf.m/cm2 J: Joule
U: J/cm2 F: ft.lbf
Fracture: S: Shear B: Brittle
Lateral Expansion: M: mm I: mil
BT Bend Test
UST: Ultrasonic Examination
G : Good

5 Gauge Length
A:200mm(■) D:50mm(■)
E:60mm(•) H:8"(■)
J:2"(•) K:50(•)
M:5.65√(•) P:5.65√(■)
R:4D(•) S:80mm(■)
U:100mm(■) Y:2"(■)

H5-3-29 NUPEC 平5.9.24

上記商品は貴社の注文指定の規格に合格していることを証明いたします。 (CAF71001) (RPQBZ743)

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN TESTED AND INSPECTED WITH SATISFACTORY RESULTS IN ACCORDANCE WITH THE REQUIREMENTS OF THE ABOVE SPECIFICATION.

野中 旭, 荒田 靖 瞬膳 石井三郎
INSPECTOR TO

京浜製鉄所：〒210 神奈川県川崎市川崎区南渡田町1番1号 KEIHIN WORKS: 1-1, MINAMIWATARIDA-CHO, KAWASAKI 210 JAPAN

N. Tanaka
京浜製鉄所検査室長
Manager of Inspection Section

SPV50-1

検査証明書
INSPECTION CERTIFICATE

NKK 日本鋼管株式会社 NKK CORPORATION

本社：〒100東京都千代田区丸の内1丁目1番2号
Head Office:1-1-2, MARUNOUCHI, CHIYODA-KU, TOKYO 100 JAPAN

注文者 Purchaser :HITACHI, LTD.-HITACHI
注文者注文番号 Purchaser's Order No. :Q402700
注文者 Trading Co. :MARUBENI CORPORATION.
注文者照合番号 Reference No. :B592 -DGN1R564
品名 Commodity :HOT ROLLED STEEL PLATE
規格 Specification :JIS G3115 SPV490 Q 1990

証明書番号 Certificate No. :AURNC-7969
日付 Date :1993-03-29
船名 Ship's No.
工事番号 Construction No. :088634
契約番号 Contract No. :AC1R564

製品番号 (注1) Roll No. / 鋼番 Heat No.	行番 Item No.	寸法 Size (MM) T X W X L	員数 Quantity	質量 Mass (CAL)	C x100	Si x100	Mn x100	P x1000	S x1000	Ni x100	Cr x100	Mo x100	V	x1000 PPM	CEQ2 (注3) x100	方向 (注4)	Y.P N/MM2	T.S N/MM2	El (注5) %	Bend (注6)	UST
SPECIFIED VALUE (STANDARD)		LADLE	:	MIN.	-	15	-	-	-						-		490	610	18		
				MAX.	18	75	160	30	30						45		- -	750	-		
TA91702 07058	001	9 X 1500 X 5000	1	1530	10	29	129	2	1	40	30	7	4		39.	TC	710	727	27	G	G
		TOTAL	1	1530 KGS																	

VISUAL & DIMENSIONS : GOOD
HEAT TREATMENT CONDITION FOR PLATE,
QUENCHED : 900 °C X 32MIN. (H.C) (ROLL NO. TA917)
TEMPERED : 650 °C X 32MIN. (A.C) (ROLL NO. TA917)

TEST SPECIMEN;
TENSILE : JIS NO. 5
BEND : JIS NO. 1

(注) (Notes)
注1 製品番号の表示 Indication of Plate Roll Number
1～5桁:母板番号 2 letter&the 1st 3 figures:mother Plate Number
7～8桁:分割番号 the last 2 figures:divided Plate Number
注2 DG:脱ガス Degassed

注3 CEQ2=C+MN/6+SI/24+NI/40+CR/5+MO/4+V/14

注4 試験片採取位置 Position
T:頂部 Top F:フランジ Flange
B:底部 Bottom W:ウェブ Web
方向 Direction
L:圧延方向 Longitudinal
C:直角方向 Transverse
Z:板厚方向 Through-thickness

衝撃試験片サイズ Size of Impact Test Specimen
1:10X10mm 2:7.5X10mm 3:2/3X10mm 4:5X10mm 5:1/3X10mm 6:2.5X10mm 7:ThicknessX10mm
衝撃試験値の単位 Unit of Impact Test Property
エネルギー Energy:K:kgf.m C:kgf.m/cm², J:Joule.
U:J/cm², F:ft.lbf
破面率 Fracture: S:延性 Shear B:脆性 Brittle
横膨出 Lateral Expansion: Mimm (mil)

注5 標点距離 Gauge Length
A:200mm(*) D:50mm(*)
E:50mm(*) H:8"(*)
J:2"(*) K:50(*)
M:5.65√(*) P:5.65√(*)
R:40(*) S:80mm(*)
U:100mm(*) Y:2"(*)

注6 BT:曲げ試験 Bend Test
UST:超音波探傷 Ultrasonic Examination
G :良 Good

H5-3-29 NUPEC

上記製品は貴注文の規格指定の要件に合格していることを証明いたします。 (CAF73001) (RPQ82743)

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN TESTED AND INSPECTED WITH SATISFACTORY RESULTS IN ACCORDANCE WITH THE REQUIREMENTS OF THE ABOVE SPECIFICATION.

INSPECTOR TO

京浜製鉄所：〒210神奈川県川崎市川崎区南渡田町1番1号 KEIHIN WORKS:1-1, MINAMIWATARIDA-CHO, KAWASAKI 210 JAPAN

M. Tanaka
京浜製鉄所検査室

A-11

SPV50-2

本社：〒100東京都千代田区丸の内1丁目1番2号
Head Office:1-1-2, MARUNOUCHI, CHIYODA-KU, TOKYO 100 JAPAN

検査証明書
INSPECTION CERTIFICATE

NKK 日本鋼管株式会社 NKK CORPORATION

購買者 Purchaser	:HITACHI, LTD.-HITACHI
購買者管理番号 Purchaser's Order No.	:9902700
注文者 Trading Co.	:MARUBENI CORPORATION.
注文者照合番号 Reference No.	:8592 -DON1R558
品名 Commodity	:HOT ROLLED STEEL PLATE
規格 Specification	:JIS G3115 SPV490 Q 1990

証明書番号 Certificate No.	:AURNC-7968
日付 Date	:1993-03-29
船名 Ship's No.	
工事番号 Construction No.	:088633
契約番号 Contract No.	:AC1R558

Heat No. / Roll No.	Item No.	Size (MM) T X W X L	Quantity	Mass (CAL)	C x100	Si x100	Mn x100	P x1000	S x1000	Ni x100	Cr x100	Mo x100	V	CEQ2 x100	Tensile Test Y.P N/MM2	T.S N/MM2	El %	Bend Test
SPECIFIED VALUE (STANDARD) LADLE : MIN.						15									490	610	18	
MAX.					18	75	160	30	30					45		790		
TA91701 07058	001	9 X 2500 X 5000	1	883	10	29	129	2	1	10	3	17	4	39	TC 696	718	27	GG
TOTAL			1	883KGS														

VISUAL & DIMENSIONS : GOOD

HEAT TREATMENT CONDITION FOR PLATE

QUENCHED : 900 °C X 33MIN.(W.C) (ROLL NO. TA917)

TEMPERED : 650 °C X 31MIN.(A.C) (ROLL NO. TA917)

TEST SPECIMEN;
TENSILE : JIS NO. 5
BEND : JIS NO. 1

(注) (Notes) 注1 圧延番号の表示法 Indication of Plate Roll Number
1上5桁:母材番号, 2 letters the 1st 3 figures: mother plate number
下2桁:分割番号, the last 2 figures: divided plate number

注2 DD: 脱ガス Degassed

注4 採取位置 Position
T: 頂部 Top P: フランジ Flange
B: 底部 Bottom W: ウェブ Web
方向 Direction
L: 圧延方向 Longitudinal
C: 圧延直角方向 Transverse
Z: 板厚方向 Through-thickness

衝撃試験片寸法 Size of Impact Test Specimen
1:10x10mm 2:7.5x10mm 3:2/3x10mm 4:5x10mm
5:1/3x10mm 6:2.5x10mm 7:Thickness x10mm

衝撃試験特性値 Unit of Impact Test Property
エネルギー Energy: K:kgf.m C:kgf.m/cm² J:Joule
U:J/cm² F:ft.lbf
破面 Fracture: S:延性 Shear B:脆性 Brittle
横膨出 Lateral Expansion: Milli Limit

注6 BT: 曲げ試験 Bend Test
UST: 超音波探傷 Ultrasonic Examination
G: 良 Good

注5 標点距離 Gauge Length
A:200mm(*) D:50mm(*)
E:50mm(*) H:8"(*)
J:2"(*) K:50(*)
M:5.65√(*) P:5.65√(*)
R:40(*) S:80mm(*)
U:100mm(*) Y:2"(*)

注3 CEQ2=C+MN/6+SI/24+NI/40+CR/5+MO/4+V/14

(CAF72001) (RPQBZ743)

上記製品は貴規格の要求事項を満足していることを証明いたします。

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN TESTED AND INSPECTED WITH SATISFACTORY RESULTS IN ACCORDANCE WITH THE REQUIREMENTS OF THE ABOVE SPECIFICATION.

H5-3-29 AMPEC 野中 加 立ち会い 日立工場検査部

INSPECTOR TO

京浜製鉄所:〒210神奈川県川崎市川崎区南渡田町1番1号 KEIHIN WORKS:1-1, MINAMIWATARIDA-CHO, KAWASAKI 210 JAPAN

N. Tanaka
京浜製鉄所検査室

A-12

SPV50-3

検査証明書
INSPECTION CERTIFICATE

NKK 日本鋼管株式会社 NKK CORPORATION

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需要家 Purchaser	:HITACHI, LTD.-HITACHI
需要家注文番号 Purchaser's Order No	:9402700
注文者 Trading Co.	:MARUBENI CORPORATION.
注文者照合番号 Reference No.	:B592 -DGN1R557
品名 Commodity	:HOT ROLLED STEEL PLATE
規格 Specification	:JIS G3115 SPV490 Q 1990

証明書番号 Certificate No.	:AURNC-7967
日付 Date	:1993-03-29
船名 Ship's No.	:
工事番号 Construction No.	:088632
契約番号 Contract No.	:AC1R557

製品番号 Roll No. / 鋼番 Heat No.	行番 Item No.	需要家注文番号(II) Purchaser's Order No. 寸法 Size (MM) T X W X L	員数 Quantity	質量 Mass (CAL)	C	Si ×100	Mn	P ×1000	S	Ni	Cr ×100	Mo	V ×1000	PPM	CEQ2 ×100	注4	Y.P N/MM2	T.S N/MM2	EL %	注5 YR %	注6	注4	IMPACT TEST 1 / 3	2 / AVE	NOTCH TEMP.	
SPECIFIED VALUE (STANDARD)		LADLE		MIN.	-	15	-	-	-						-		490	610	25							
				MAX.	18	75	160	30	30						45		-	740	-							
		(CUSTOMER'S SPEC.)																				1J	MIN.	27	2MM V	EACH
																							MIN.	47	-10°C	AVE.
																						1K	MIN.	3.4	2MM V	EACH
																							MIN.	5.1	-25°C	AVE.
TA91801 07058	001	38 X 1000 X 3000	1	895	10	24	129	2	1	40	3	17	4		39	TC	566	650	45		GG	TC1J	364 370	367 367	2MM V -10°C	
																						TC1K	35.7 36.7	37.4 36.6	2MM V -25°C	
		TOTAL	1	895KGS																						

VISUAL & DIMENSIONS : GOOD

HEAT TREATMENT CONDITION FOR PLATE
QUENCHED : 900 °C X 48MIN. (W.C)
(ROLL NO. TA916)
TEMPERED : 615 °C X 1HR.27MIN. (A.C)
(ROLL NO. TA916)

TEST SPECIMEN:
TENSILE : JIS NO. 5
BEND : JIS NO. 1
IMPACT : JIS NO. 4

(注) (Notes)
注1 製品番号の表示方法 Indication of Plate Roll Number
1〜5桁:母板番号 2 letter&the 1st 3 figures:mother Plate Number
下2桁:分割番号 the last 2 figures:divided Plate Number
注2 DG:度(ド) Deg

注4 採取位置 Position
T:頂部 Top F:フランジ Flange
B:底部 Bottom W:ウェブ Web
方向 Direction
L:圧延方向 Longitudinal
C:直角方向 Transverse
Z:板厚方向 Through-thickness

衝撃試験片寸法 Size of Impact Test Specimen
1:10x10mm 2:7.5X10mm 3:2/3X10mm 4:5X10mm
5:1/3X10mm 6:2.5X10mm 7:ThicknessX10mm
衝撃試験単位 Unit of Impact Test Property
エネルギー Energy:K:kgf.m C:kgf.m/cm2 J:Joule.
U:J/cm2 F:ft. lbf
破面 Fracture: S:延性 Shear B:脆性 Brittle
横膨出 Lateral Expansion: M:mm I:mil

注5 標点距離 Gauge Length
A:200mm(*) D:50mm(*)
E:50mm(*) H:8" (*)
J:2" (*) X:50D(*)
M:5.65√(*) P:5.65√(*)
R:40(*) S:80mm(*)
U:100mm(*) Y:2" (*)

注3 CEQ2=C+MN/6+SI/24+NI/40+CR/5+MO/4+V/14

注6 BT :曲げ試験 Bend Test
UST :超音波探傷 Ultrasonic Examination
G :良 Good

H5-3-29, NUPEC 平5.3.29

上記商品は表記の規格指定の値に合格していることを証明いたします
WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN TESTED AND INSPECTED WITH SATISFACTORY RESULTS IN ACCORDANCE WITH THE REQUIREMENTS OF THE ABOVE SPECIFICATION.

(CAF73001) (RPQBZ743)

INSPECTOR TO

京浜製鉄所：〒210 神奈川県川崎市川崎区南渡田町1番1号 KEIHIN WORKS:1-1, MINAMIWATARIDA-CHO, KAWASAKI 210 JAPAN

N. Tanaka
京浜製鉄所検査室
Manager of Inspection

INSPECTION CERTIFICATE

Heat No.	Material	Size (mm)			Chemical Composition (%)									Tensile Test (N/mm²)		El
		T	W	L	C	Si	Mn	P	S	Ni	Cr	Mo	V	Y.S	T.S	(%)
TG86001	SGV480	6	×1000	×3000	0.18	0.26	1.14	0.006	0.001					384	568	22
SN91401	SGV480	7.5	×1500	×4000	0.18	0.23	1.16	0.007	0.001					403	556	26
TF89201	SGV480	8	×1500	×3000	0.18	0.23	1.16	0.007	0.001					389	532	26
SN91501	SGV480	8.5	×2500	×4500	0.18	0.23	1.16	0.007	0.001					411	560	24
SN91201	SGV480	10	×3000	×4500	0.18	0.23	1.16	0.007	0.001					406	562	24
SN91301	SGV480	38	×1000	×3000	0.18	0.23	1.16	0.007	0.001					366	529	31
TA91702	SPV490	9	×1500	×5000	0.10	0.24	1.29	0.002	0.001	0.48	0.03	0.17	0.04	710	727	27
TA91701	SPV490	9	×2500	×5000	0.10	0.24	1.29	0.002	0.001	0.48	0.03	0.17	0.04	698	718	27
TA91601	SPV490	38	×1000	×3000	0.10	0.24	1.29	0.002	0.001	0.48	0.03	0.17	0.04	566	650	45

T : Thickness
W : Width
L : Length

Y.S : Yield Stress
T.S : Tensile Strength
EL : Elongation

Appendix B

All Sample Hardness Measurements (Rockwell B Scale)

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Listing of All Sample Hardness Measurements (Rockwell B scale)

Sample	Material	Zone Description	Average (x)	Std. Dev. (s)	Raw Data									
Plate	SPV490	**Reference Plate**	98.8	0.7	99.2	98.1	97.6	98.4	98.6	100.1	98.5	99.2	99.0	98.8
SCV-74-1	SPV490	**Base Metal**	98.1	1.0	98.8	99.6	98.4	98.7	98.0	96.5	96.3	99.1	98.5	97.4
		HAZ	91.5	1.1	92.8	92.1	90.1	90.4	92.1					
		Fusion Zone	95.1	1.1	95.5	94.7	96.4	95.6	93.3					
SCV-74-3	SGV480 (Side)	**Base Metal**	89.18	0.15	89.0	89.1	89.3	89.1	89.4					
		HAZ	92.20	1.49	89.9	94.3	91.4	92.3	93.1					
	SPV490 (Side)	**Base Metal**	94.24	0.39	94.8	94.4	93.9	93.7	94.4					
		HAZ	90.82	1.80	90.1	89.3	89.2	92.2	93.8					
		Fusion Zone	92.10	0.96	92.7	90.2	92.6	92.7	92.3					
SCV-106-1	SPV490	**Base Metal**	97.36	1.22	97.4	98.6	97.2	99.0	97.2	96.6	96.2	97.5	96.6	96.4
					97.1	96.2	95.5	97.2	100.0	97.6	96.5	96.5	98.0	100.3
		HAZ	92.06	1.69	95.1	92.7	91.0	91.0	90.5					
		Fusion Zone	97.21	1.11	98.6	98.6	97.8	97.3	98.4	96.3	95.5	95.8	95.9	96.7
					97.6	98.4	96.2	98.6	96.4					
SCV-106-2	SPV490	**Base Metal**	96.96	1.34	94.8	95.4	95.3	96.4	99.8	97.4	98.6	97.2	99.0	97.2
					96.6	96.2	96.5	96.6	96.4					
		HAZ	88.64	1.04	90.1	89.5	87.3	87.8	88.5					
		Fusion Zone	94.93	2.58	94.1	94.7	96.5	98.3	98.9	91.7	90.6	92.7	96.1	95.8
SCV-340	SPV490	**Base Metal**	97.93	0.84	96.8	99.1	99.0	96.5	96.8	98.3	98.5	98.7	98.3	98.4
					98.3	98.3	97.9	98.1	98.5	96.8	97.9	96.2	97.5	98.7
		HAZ (areas of minimum deformation)	96.65	1.83	93.8	97.0	97.5	98.3	92.9	98.4	98.1	97.7	97.2	95.6
		Fusion Zone	97.63	0.55	97.1	97.7	98.1	97.2	96.4	97.3	97.6	98.4	97.8	98.1
					98.6	97.4	97.8	97.7	97.2					
SCV-21	SGV480	**Base Metal**	88.82	1.26	89.7	90.3	90.0	88.4	87.3	87.2				
		HAZ (undeformed area)	92.75	0.56	92.6	92.4	92.3	93.7						
		HAZ (deformed area)	95.08	2.27	91.0	94.7	95.3	97.1	97.3					
		Fusion Zone	95.53	0.82	95.9	94.6	95.7	97.3	94.7	95.0				

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